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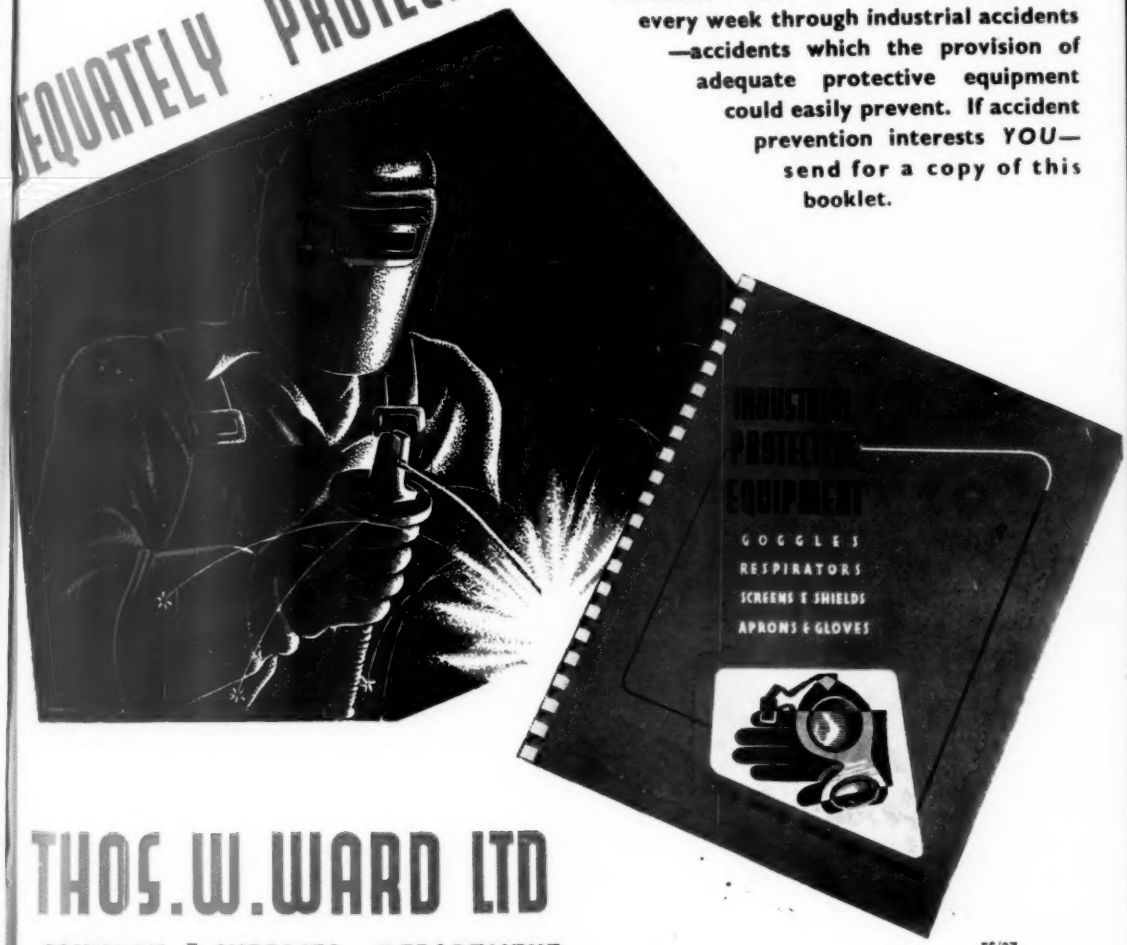

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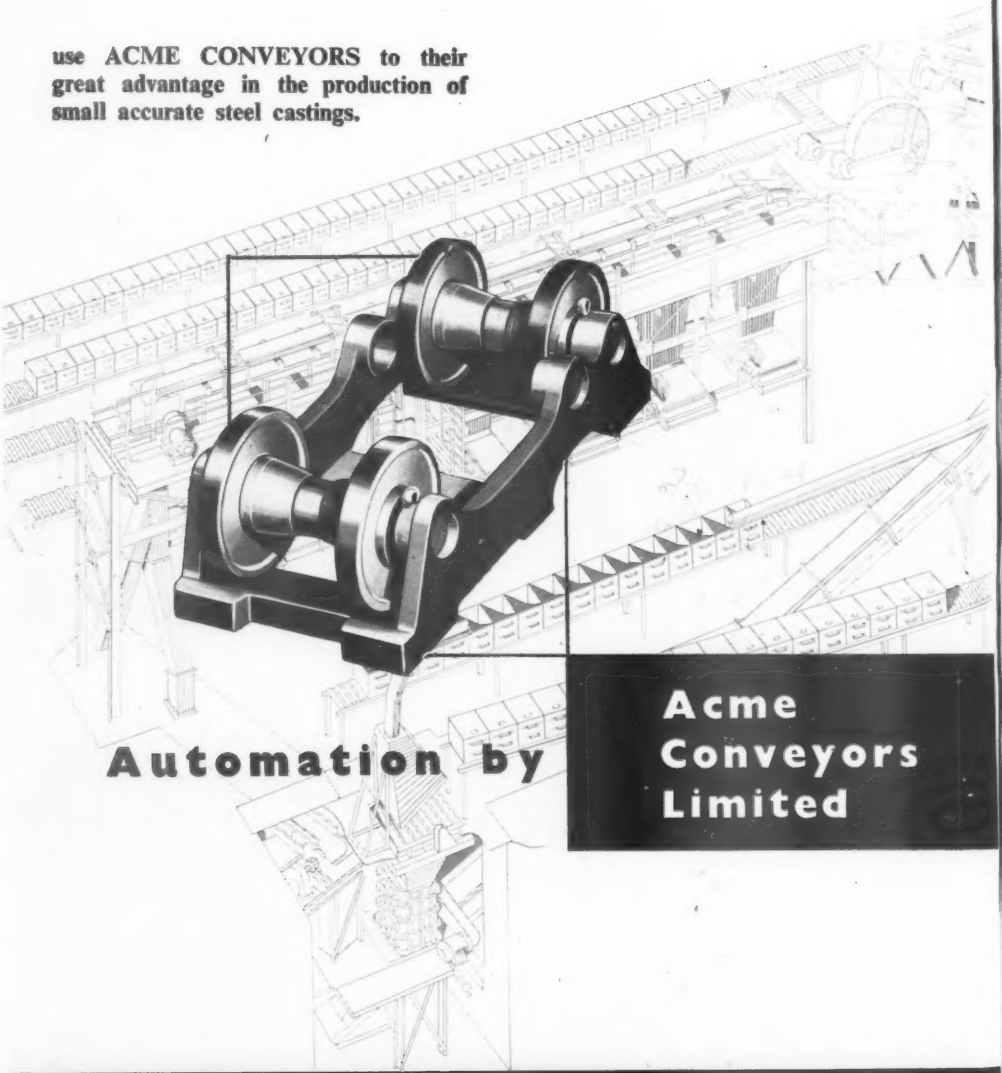

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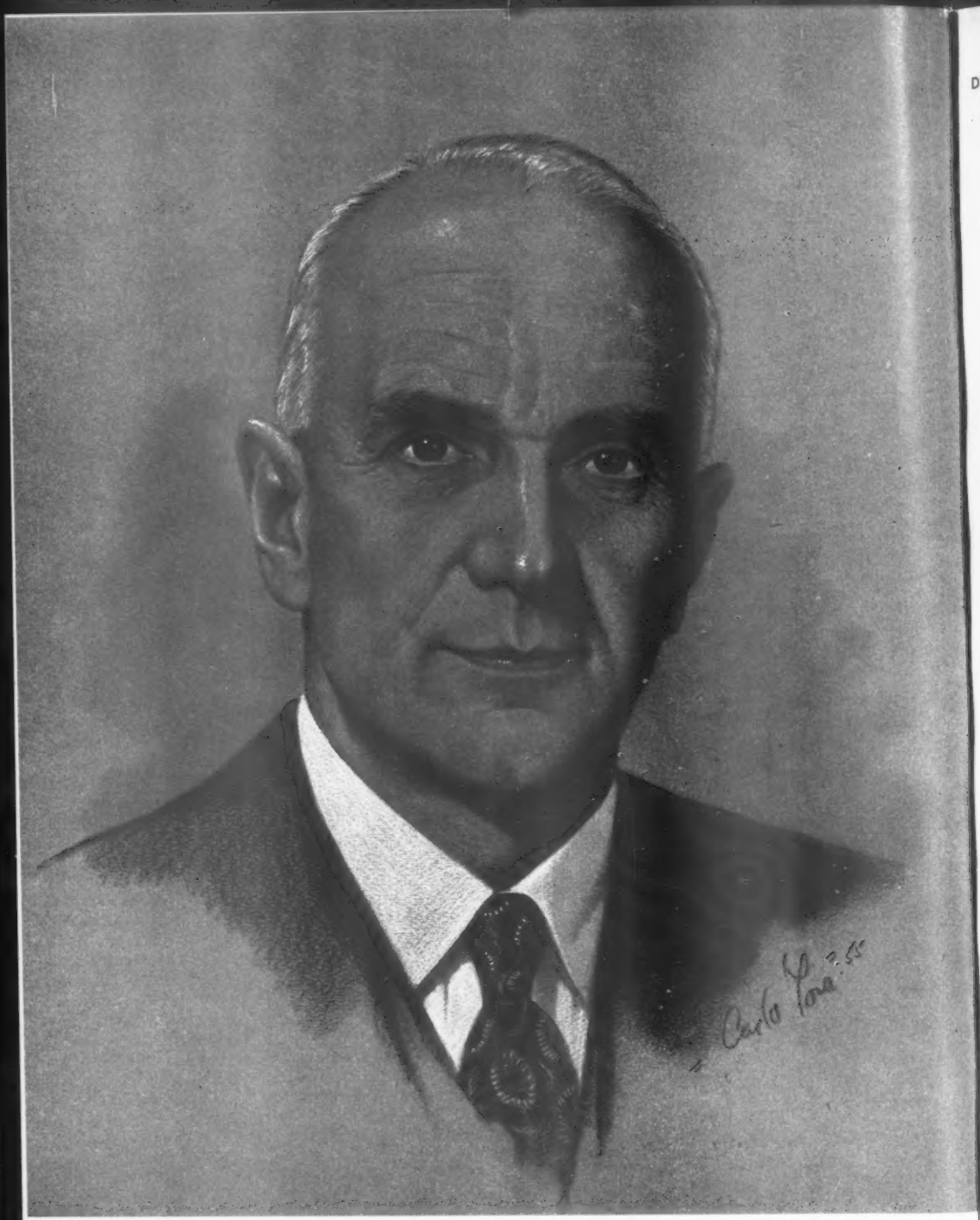
Growing Pains

It is barely 18 months since we first commented on the potentialities of the CO_2 Process. Whilst we then envisaged substantial development in its application, the actual growth is bordering on the phenomenal. We anticipated mechanization, and a film covering the Process is now available which includes illustration of the mass-production of cores side-by-side with mould making—and thereby reducing to the minimum handling and conveying problems. A factor which we did not realize at the time of our earliest writing on the subject (for we had then never seen the Process in operation) was the potential use of the Process as an emergency tool. The closing of a complicated one-off mould need no longer be delayed because of a last-minute breakage of a core, as a fresh one can be supplied very quickly. Again, for rapid testing of the dimensional accuracy of cores stripped from new boxes, this new Process is ideal.

The range of application of the CO_2 Process is particularly wide, and it is in use for all the usual foundry alloys, in shops as vastly different as those devoted to die-castings and to the making of very heavy steel components. It has made its appeal because of the elimination of fuel, much reduced handling costs and minimum demands on space. The supply of the gas, be it merely an odd cylinder, or in solid or liquid form for bulk usage, has been well developed and there are but few cases of difficulty in getting adequate service. The piping of CO_2 to the points of consumption, the necessity for de-icing, and pressure-reduction have created no great problems, but there have been and will continue to be " snags."

Thus it has been particularly pleasing to learn of the record attendances at branch meetings of the Institute of British Foundrymen when this subject has been discussed. Unreservedly, users of the process have disclosed their troubles and received advice from others as to remedies. By now, all sorts of materials, such as coal-dust, wood-flour, sulphite-lye and pelleted pitch have been incorporated to achieve and maintain various foundry properties in the sand. Shellac varnish on patterns, as with the cement-moulding process, is best replaced by cellulose compounds. A new " snag " has been ascribed to ice formation in certain moulds, yet whatever difficulties be encountered, their ventilation in open meeting is of general benefit. A problem still to be faced is the accumulation of sodium carbonate in the sands. So far, two solutions have been postulated. The first is weathering of used sand in the open over a long period and the second washing and grading of the type often incorporated by the Hydro-blast apparatus. We suggest a third, namely, that as the future will see more and more washing plants installed in the sand quarries, such quarries would seem to be a suitable locale for reclamation.



G. L. BAILEY, C.B.E., M.Sc., F.I.M.

Director, British Non-Ferrous Metals Research Association.

Leaders of the Industry

G. L. BAILEY, C.B.E., M.Sc., F.I.M.

MR. G. L. BAILEY was born in 1901 and educated at King Edward VI grammar school and at Birmingham University, where after graduation he held a Bowen Research Scholarship in the Metallurgy Department and carried out post-graduate research, for which he was awarded the M.Sc. degree.

His first post was in the metallurgical branch of the Research Department, Woolwich, where he was engaged on work, sponsored by the British Non-Ferrous Metals Research Association, on the casting of brass ingots. The results of this work were incorporated in the book *Casting of Brass Ingots* which he wrote jointly with Dr. R. Genders and which now, a generation later, is still a classic in its field; it has also appeared in a German translation.

In 1930, he joined the staff of the British Non-Ferrous Metals Research Association, which he has served as chief officer of the Development Department, deputy director of the Association and since November, 1944, as director. He has published and lectured extensively on technical subjects in the non-ferrous field, also on the organization of research and development in the industry and on related subjects.

Mr. Bailey has taken an active part in metallurgical affairs and societies. He has been a vice-president of the Institute of Metals and a member of a number of its committees; is a founder member and a vice-president of the Institution of Metallurgists, in which he was until recently hon. treasurer; has served on various committees of the Ministry of Supply and the Admiralty; and is a member of the Inter-Service Metallurgical Research Council and a former chairman of its Non-Ferrous Metals Committee. For many years he has been much engaged in the work of the British Standards Institution and recently he completed a two-year term of office as chairman of the Committee of Directors of Research Associations. He was awarded a C.B.E. in the New Year Honours List in 1952.

He is of course widely known in the foundry industry, not only through his present position but also from the period when he served as chief development officer of the Association and was personally responsible for fostering industrial applications of the Association's well-known investigations on the founding of aluminum, copper and magnesium alloys. For over 23 years he has been a member of the Institute of British Foundrymen and holds its diploma award.

Congress Paper Authors

Given below are short biographical notes of the four Authors of the Belgian Exchange Paper, "Metallurgical Studies on the M.B.C. and ADS Cupolas," printed on the facing page.

PROF. A. DE SY.

R. DOAT.

R. BALON.

L. WINANDY.

PROFESSOR ALBERT DE SY was educated at Ghent University, where he graduated in 1933 with the diplôma *Ingénieur Civil des Mines*. From 1933 to 1935 Professor De Sy had practical experience in the metallurgical industry, and in the latter year returned to the University of Ghent as a lecturer. Since 1940 he has been a professor of metallurgy at the University and director of the metallurgical and metallographic laboratory. He is a consultant to the C.N.R.M. (Hainaut) and is a member of the Iron and Steel Institute, the American Foundrymen's Society, as well as of the Belgian Foundrymen's Association.

ROBERT DOAT is a director of the Compagnie Générale des Conduites d'Eau at Liège. He is a member of Council of the Belgian Foundrymen's Association and holds the diplôma of *Ingénieur Civil Métallurgiste, Université de Liège.*

ROGER BALON is an engineer at the Compagnie Générale des Conduites d'Eau at Liège, where he is attached to the department dealing with metallurgical installations. Mr. Balon, who is secretary of the technical committee of the Belgian Foundrymen's Association, holds the diplôma of *Ingénieur techn. I.G.Lg.*

LUCIEN WINANDY, who is also an engineer at the Compagnie Générale des Conduites d'Eau at Liège, is employed in the company's metallurgical research department and holds the diplôma of *Ingénieur Civil Chimiste, Université de Liège.*

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gress are asked to send their names to the secretary of the Institute, who will be very glad to forward all information as it becomes available during the next few months.

Light Metal Founders' Association

During the course of a short speech given at a luncheon* of the Light Metal Founders' Association on November 17, the Rt. Hon. Reginald Maudling, the Minister of Supply, referred to the problems which faced the UK in maintaining and expanding its export trade upon which so much was dependent. He pointed out that competition was growing all the time, and with the re-entry of Germany and Japan into the ranks of competitors it had to be expected that the UK should yield back some of the trade to those countries, but it was disturbing that the UK share of the export markets was declining while world trade was expanding.

He referred to the new problems which faced his department in connection with the development and production of the complex modern weapons required for the defence of the Commonwealth and stated that this country could not afford to fall behind in these most important matters, but at the same time it could not take the risk of abandoning the more conventional existing weapons. The part played by the metallurgical industry both in the export sphere and in defence projects was a great one which perhaps few recognized, and he referred to the enormous growth in the production of light-metal castings in recent years, pointing out that in 1955 production was approaching 100,000 tons per year.

One serious drawback was the lack in this country of scientific manpower. Britain's resources were small in comparison with the scientific resources of such countries as America and Russia and, therefore, it was essential that the most effective use should be made of the great experience and knowledge within UK industries. For this reason, he felt that the industrial trade associations were playing an extremely important part in securing the concentration of knowledge and mutual help to improve the efficiency of the industries and he appreciated greatly the co-operation and help which his department received from the Light Metal Founders' Association.

* The luncheon was reported briefly in last week's issue.

Patternmakers visit West Yorkshire

The meeting of the National Society of Master Patternmakers on November 16, in Leeds, included a works visit to the West Yorkshire Foundries, Limited; 32 members and guests took part. Before moving off, Mr. B. Levy, the president, gave a brief address to the assembly at the Queens Hotel, outlining the activities of the Society. At West Yorkshire Foundries, Limited (which was visited on the invitation of Mr. C. Robertson, a director), they were received by officials of the firm and the party split into small groups for inspecting the works. There was much of interest for the visitors in touring the patternshop, die-shop and toolroom, iron foundry and aluminium die-casting foundry. Tea was provided by the firm and everyone joined the president in passing a sincere vote of thanks to their hosts.

1956 International Foundry Congress

Preliminary information has been received regarding the 23rd International Foundry Congress which will be held at Dusseldorf, Germany, from September 1 to 9, 1956, in conjunction with an International Foundry Trades Fair. Members of the Institute of British Foundrymen who are interested in attending the Con-

(*Continued at foot of col.* 1)

Metallurgical Studies of the M.B.C. and ADS Cupolas*

By Professor A. De Sy, Robert Doat, Roger Balon and Lucien Winandy

Both the cupolas dealt with in this Paper have the common chief objective of the stabilization of the refractory in the melting zone by means of water cooling. This eliminates all subsequent contamination of the slag during melting. In other words, the estimated composition of the slag charged will approximate very closely to that of the slag actually formed. Thus, as is shown in the Paper, the slag, by its composition and volume, can constitute a key to the control of the properties of the iron to be melted. Thereby, it is possible efficiently to control and maintain the iron produced precisely within the desired analytical limits. Obviously, the other factors to be associated with the running of a cupola are taken into consideration, i.e., *the nature of the blast, its temperature, the coke : metal ratio, etc. As well as improvement in the quality of the irons melted, there are outstanding economic advantages—use of cheaper raw materials and a noteworthy reduction in the consumption of refractory and the cost of patching.*

Ever-increasing demands for better quality and lower prices of cast iron have caused the foundryman with a preference towards the traditional means of melting—that is, the cupola—to examine more closely its functioning and to endeavour to widen its usefulness. A large number of efforts have been made in both directions in many countries, as the cupola is still the most economic and elastic melting unit. Even when of the best design, meticulously controlled, and having the same installation costs, its production capacity is distinctly higher than any other melting apparatus, whilst its operating costs are distinctly lower.

Of outstanding interest to foundrymen in connection with melting practice is the recent American statement that in the larger foundries of that country, 36 per cent. of the cupolas have been installed within the last five years. Many, however, do not envisage the cupola as anything other than a remelting plant.

The two cupolas, the M.B.C.[1] and the ADS,[2] dealt with in this Paper are a novel development, and it is hoped to show that they are really plant for producing cast iron of controlled properties. The slag, as will be shown, is the cardinal factor in controlling the diverse key elements in the metal, and this control depends on the composition of the slag. The proper control of the slag can only be carried out in the absence of any erosion of the cupola refractories and herein is the essential characteristic common to the two systems.

The M.B.C. operates on hot blast, under extremely reducing conditions, and permits the making of iron using 100 per cent. second-quality steel scrap. The ADS is a cold-blast furnace and normally uses on the charge from 40 to 100 per cent. of good steel scrap, according to the method of running adopted.

The Paper submitted is designed quite simply to show with what precision in both cases the desired composition of the iron can be made.

A.—RESULTS FROM THE M.B.C. CUPOLA

The M.B.C. cupola is now well enough known and does not require detailed description. Its main features are, however, worth recalling. It operates with a reducing atmosphere which is obtained by preheating the blast and through proper layout of the tuyeres (this reducing operation reveals itself by a normal FeO content of the order of 0.3 per cent. in the slag); constancy in the composition of the slag—obtained by suppressing lining wear by exterior cooling—and of its depth in the cupola well obtained by a special system for continuous casting.

The results of tests to be detailed are based on a systematic study of the metallurgy of the M.B.C. They have been applied to the making of synthetic iron. The metallic charge consisted solely of steel scrap and ferro-silicon. The chief object was to determine the influence of the various factors of the operation on the Si, C and S contents of the irons. Data as to P and Mn are obtained from current practice and from a separate series of tests.

The plant used was the M.B.C., of which the diameter after lining was 500 m.m. (20 in.). It is a small-scale replica of basic design of the M.B.C. cupola—except as to the slagging and continuous casting—on account of its small output. Thus it casts intermittantly and not continuously. The lining is made of mullite bricks up to 20 in. above the tuyeres, and from here to the bottom of the cupola it is rammed up with a silicious material carrying a proportion of graphite (Neutromelt). A marked erosion of the refractory takes place during the first melt, but thereafter the profile is stable and has the shape shown in Fig. 1. Before detail-

* Researches carried out under the auspices of the I.R.S.I.A. and C.R.I.F.(Fabrimetal), comprising the Official Exchange Paper from *l'Association Technique de Fonderie de Belgique*, presented at the International Foundry Congress in London, last June.

M.B.C. and ADS Cupolas

ing the results, it is germane to point out the implications of various expressions to be used:—

Corrected SiO_2 per cent. represents the percentage of this material as a ratio of the sum of $SiO_2 + Al_2O_3 + (CaO + 1.4\ MgO)$, MgO being replaced by its equivalent of CaO.

Pf/Pl = ratio between the weights of the iron and the slag.

Charged slag = the slag which would result from the reaction of the coke ash and of the silica—arising from the oxidation of the Si—with the fluxes.

$$P = \frac{CaO + MgO}{SiO_2 + Al_2O_3} = \text{Index of basicity.}$$

P Si per cent. = Melting loss of silicon expressed as a percentage of the silicon charged.

C/Me = Carbon charged as a ratio of the cold metal. This formula allows a comparison

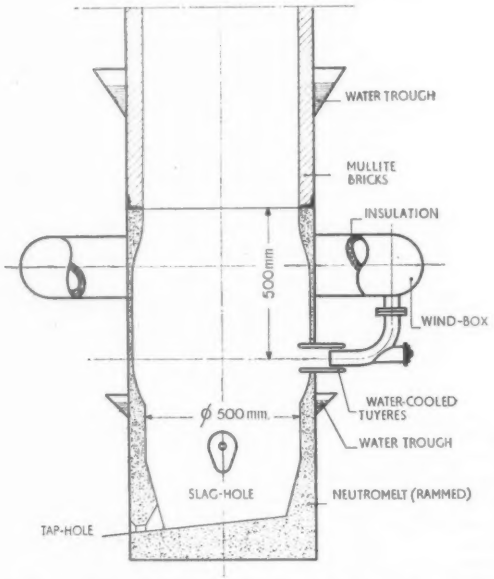


FIG. 1.—*General construction of the lower section of the experimental M.B.C. cupola.*

to be made between cokes carrying different ash content.

I—Description of Tests

Two series of tests were made to evaluate the influence of the nature of the slag and the percentage of coke on properties of the iron.

(*a*) *Influence of the Slag*

The following factors, which are independent of the nature of the slag, have been chosen:—

Coke.—The coke used was always from the same source. An agreement guaranteed its coking under identical conditions, starting off with coal mined from one specific face in the same pit. The composition of this coke varied between the following limits.

Ash	6.4 to 8.1 per cent.
S	0.49 to 0.59 per cent.
Volatiles	1.1 to 1.5 per cent.

The percentage of coke was calculated to give a C/Me ratio of 0.345. This high value was chosen to limit the importance of the thermal effect due to the variation of the quantity of flux when the composition of the slag was being modified.

Blast.—The temperature of the blast varied between 530 and 570 deg. C.

Blowing.—3,450 cub. m. per sq. m. per hr.

Fluxes used.—Aluminous cement later designated by the letter A; silica pebbles as B and limestone as C.

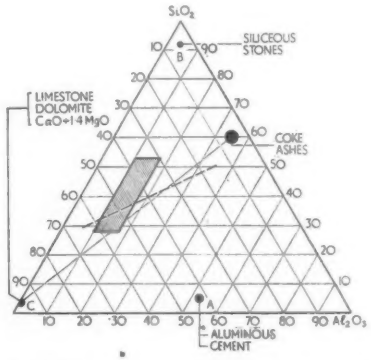


FIG. 2.—*Composition of materials charged and slags obtained.*

In Fig. 2 are shown the composition of these materials used and the zone of the slags obtained. On this graph a coke-ash/limestone line has been drawn and this corresponds to the line for the evolution of the slags normally charged, leaving out of consideration the loss of silicon. The broken line represents this evolution modified by the positive or negative silicon change. The results of this first series of tests are detailed in Table I.

The normal elements of cast iron and slags detailed in Table I have been submitted to statistical analysis. In each case there has been chosen the slag element giving the best pointer for the phenomenon studied.

(*b*) *Influence of Coke Percentage*

The coke was the same as for the first series of tests. The blast temperature varied from 515 to 545 deg. C. As fluxes, only limestone and dolomite were used. The results are set out in Table II.

II—Results from Metallurgical Investigations

Fig. 3 shows the relationship between the SiO_2 contents in the slag charged and the slags obtained, and illustrates the noteworthy precision with which any desired composition can be attained. The

TABLE I.—*Results from First Series of Tests.*

No.	Flux used.	SiO_2.	CaO + MgO.	Corrected SiO_2.	Pf/Pl.	Si charged	C.	S.	PSi.
1	C	31.6	53.2	30.9	10.4	2.13	3.97	0.024	16.0
2	,,	34.9	51.3	34.1	10.0	3.51	3.75	0.031	21.6
3	,,	32.1	54.2	31.2	10.0	3.51	3.96	0.018	22.1
4	,,	35.9	49.6	35.4	10.8	2.84	3.71	0.050	24.7
5	,,	36.2	48.0	35.9	11.0	3.18	3.54	0.037	14.5
6	,,	33.3	51.5	32.7	11.2	2.59	3.83	0.042	26.6
7	,,	30.9	53.4	30.2	12.7	2.00	3.83	0.049	28.0
8	,,	30.5	54.5	29.7	10.4	2.93	3.85	0.033	30.6
9	,,	40.6	39.4	40.1	8.5	2.7	3.45	0.078	− 9.0
10	B + C	43.2	38.0	43.6	8.5	2.7	3.37	0.083	−11.0
11	,,	41.7	41.2	41.2	8.5	2.7	3.73	0.052	− 3.5
12	,,	39.2	41.5	38.6	8.5	2.7	3.68	0.042	− 3.5
13	,,	35.8	46.1	35.4	8.5	2.07	3.88	0.038	15.5
14	,,	32.5	54.5	32.0	8.5	2.07	4.02	0.019	20.2
15	C	35.8	46.6	36.2	14.1	2.33	3.60	0.057	14.6
16	,,	36.2	48.1	36.6	14.1	2.33	3.61	0.051	11.6
17	A + B + C	47.7	31.8	48.2	8.5	2.33	2.86	0.133	−24.3
18	,,	49.5	29.6	50.5	8.5	2.33	2.83	0.116	−11.2
19	,,	50.7	27.9	52.9	8.5	2.33	2.78	0.112	−31.0
20	,,	49.6	33.2	50.1	8.5	2.33	2.74	0.104	−11.2
21	,,	48.5	33.9	50.2	8.5	2.33	2.91	0.098	−24.5
22	,,	45.5	37.1	45.7	8.5	2.33	3.06	0.090	− 7.0
23	,,	41.2	41.2	41.3	8.5	2.33	3.22	0.063	−18.0
24	,,	38.8	43.2	38.6	8.5	2.33	3.35	0.059	− 2.5
25	C	29.3	51.4	29.3	13.2	2.33	3.94	0.033	16.3
26	,,	32.5	51.3	32.7	13.2	2.33	3.76	0.033	25.6
27	,,	29.7	54.1	29.7	13.2	2.33	4.05	0.025	25.6
28	,,	29.6	54.8	29.3	13.2	2.33	3.87	0.027	30.4
29	,,	29.7	54.8	29.3	13.2	2.33	3.96	0.028	27.4
30	,,	30.4	52.1	30.0	13.2	2.33	4.03	0.030	31.2
31	,,	29.6	53.1	28.6	13.2	2.33	3.90	0.032	30.4
32	,,	32.2	50.4	31.2	13.2	2.33	3.90	0.034	19.2
33	,,	32.5	50.3	30.0	13.2	2.33	3.89	0.034	19.2
	Average	36.9	46.1	36.7	10.7	—	3.60	0.053	10.2

balance of this composition is regular; the following table gives in respect to the envisaged composition the hour-to-hour results for one melt:—

Per cent. CaO sought	Per cent. CaO obtained.								
53.4	52.1	54.5	54.6	56	55.8	53.6	54.6	53.6	52.7

(*a*) *M.B.C. in relation to P, Mn and Si Control*

Phosphorus.—The commercial operation of several M.B.C. plants involves the making of a grey iron containing 0.6 per cent. P starting off with 100 per cent. steel scrap. This phosphorus content is obtained through the reduction of P_2O_5 present in basic slag (8 per cent. P) or phosphates added to the charge. The residual content of P in the slag is practically nil (analytical traces).

TABLE II.—*Results from the Second Series of Tests.*

No.	C/Me.	Blast vol. cub. m. per sq. m. per hour.	CaO charged.	SiO_2 correction.	C.	S.
101	0.403	3,450	70	33.5	4.40	0.007
102	0.374	3,450	69	33.5	4.15	0.010
103	0.346	3,450	68	27.9	4.08	0.017
104	0.346	3,450	69	33.1	4.15	0.009
105	0.346	3,430	69	36.7	4.03	0.009
106	0.316	3,430	69	30.7	4.05	0.012
107	0.288	3,450	69	38.2	3.80	0.030
108	0.230	3,470	69	38.2	3.41	0.034
109	0.340	3,400	56	35.4	3.72	0.050
110	0.283	2,830	56	34.8	3.60	0.038
111	0.256	1,560	57	37.0	3.20	0.070
112	0.227	2,270	56	34.0	3.35	0.046
113	0.222	2,370	56	42.3	2.62	0.078
114	0.222	2,370	56	42.3	2.85	0.075
115	0.198	1,980	56	32.5	3.00	0.050
116	0.194	3,000	56	36.6	2.70	0.075
117	0.183	3,400	56	39.6	2.85	0.060
118	0.170	1,700	56	32.5	2.70	0.050
119	0.169	3,140	56	39.6	2.92	0.065
120	0.155	3,400	57	39.0	2.80	0.060
121	0.346	2,720	53	38.2	3.40	0.080
122	0.346	3,450	53	36.1	3.85	0.045
123	0.181	3,240	48	37.4	2.87	0.090
124	0.141	2,700	48	39.4	2.51	0.103
125	0.128	2,320	48	43.3	2.33	0.090

M.B.C. and ADS Cupolas

Manganese.—The loss in manganese is virtually nil. In the commercial operation of the M.B.C., the manganese content in the steel charged is thus sufficient to counterbalance the effect of the small content of sulphur in the iron. This is why no account has been taken of the element in the tests described. However, other tests have shown that this reduction is easy and becomes still more pronounced as the basicity of the slag increases.

Silicon.—The loss in silicon (positive or negative) has been covered in the first series of tests and the results are set out in Table I. It would appear, therefore, that with constant coke, the chief variable is the composition of the slag. The results are shown in Fig. 4, the examination of which reveals that the silicon loss is proportional to the silicon charged. This permits the expression of this loss as a percentage. On the other hand, it increases linearly with the CaO + MgO content. It is shown that this loss becomes negative for slags, the CaO + MgO content of which is less than about 40 per cent. ($P<0.75$). In this zone, to express the gain in silicon as a function of the Si charged is no longer acceptable. That is why the line representing the loss in Si figures as a broken line.

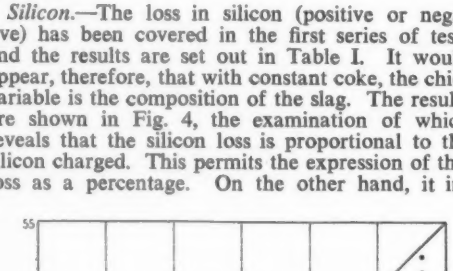


FIG. 3.—*Correlation between slags charged and obtained.*

(*b*) *Carbonization*

Influence of Slag.—An examination of Table I immediately calls attention to the importance of the composition of the slag on the nature of the iron produced and notably on the carbon content, which varies in these tests from 2.74 to 4.05 per cent., due solely to the modification of this factor.

It is thus possible with the M.B.C. to control every aspect of normally-used foundry irons. Fig. 5 shows the relationship between the total carbon of the iron and the corrected SiO_2 content of the slag. The carbon content decreases with increasing SiO_2 content of the slag, in a virtually linear manner.

It is apparent that the slags made from fluxes compounded of limestone and silicious pebbles (B + C) correspond with higher carbon contents than the average of the tests, where again the irons made under these conditions seem to have been made with more basic slags.

Influence of Coke.—The tests carried out do not clearly identify the influence of coke in the carbon content of the iron. Nevertheless, the result of the tests, as far as possible, have been set out in Fig. 6, which is that increase in the percentage of coke brought about an increase in the carbon of the iron. The dispersion shown is due to the fact that during the course of the tests the composition of the slags was also varied. The dispersion could be largely reabsorbed by corrections taking into consideration the influence of this factor. This influence having been solely determined for high percentages of coke, one could not apply this correction to the tests made with much lower percentages of coke, and therefore it has been thought better to present the results as they are.

FIG. 4.—*Relation between slags and silicon losses.*

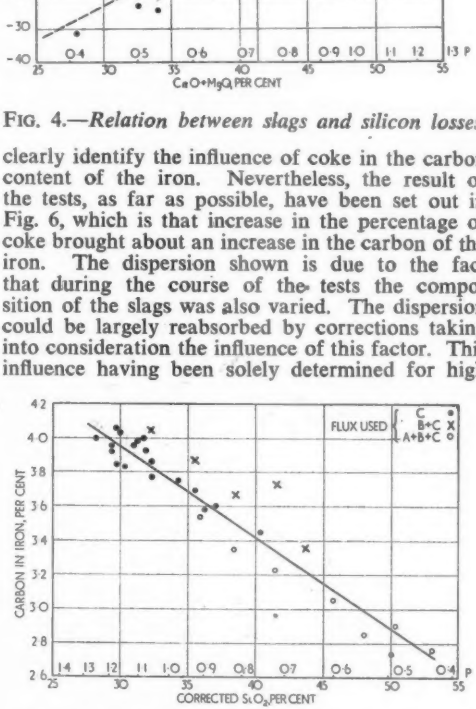


FIG. 5.—*Relation between slag and carbon content of the iron.*

(*c*) *Desulphurization*

Influence of Slag.—The sulphur contents of the irons detailed in Table I are graphed in Fig. 7 as a

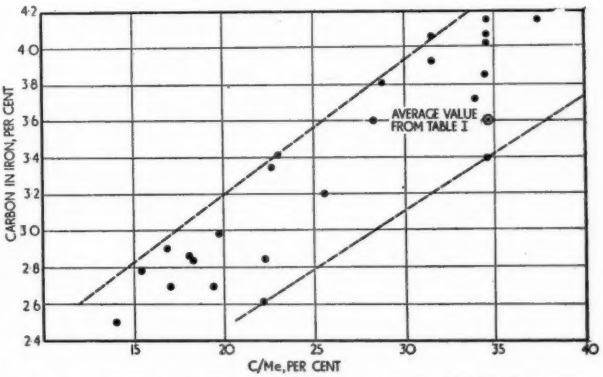


FIG. 6.—*Relation between carbon content in the iron and coke percentage.*

function of the CaO + MgO. These contents decrease with the increasing basicity of the slag, up to a minimum of 0.018 per cent. It should be pointed out that the charge was 100 per cent. steel scrap and ferro-silicon, with a sulphur content of the order of 0.040. The points corresponding to the slags composed of limestone and silicious pebbles (B and C) called for the earlier observation; these slags act with an efficiency higher than that corresponding to their basicity.

Influence of the Percentage of Coke.—Within the limits studied, the influence of this factor is not apparent.

(*d*) *Relation between C. and S. Contents of the Iron* The carbon and sulphur contents in the tests, shown as a percentage of constant coke charge, group themselves very orderly in the graph of Fig. 8. The relationship between the contents vary with the percentage of coke. When the latter is lowered, the total quantity of sulphur introduced into the furnace evidently decreases. It has been shown earlier that in this case, the carbon content equally decreases (influence of coke on carbon).

If it be desired to maintain the carbon at its initial value, the slag should be controlled and made more basic, which brings about more intensive desulphurization. Without wishing to exceed the limits of this investigation, the following conclusion can be drawn so far as the M.B.C. is concerned:—

It has previously been shown that the relations between C. and S. and the slag were practically linear. There is thus no reason to doubt the linear slope of the diagram C.S. It is, however, germane to draw attention to the divergencies which are much less than those of Figs. 5 and 7 and even more so than the singular points of the slags composed of the limestone and silicious-pebble flux (B and C). In other words, the reactions of carbonization and desulphurization vary in a parallel sense.

B—COMMERCIAL OPERATION OF THE ADS CUPOLA

The ADS cupola is basic lined and is water cooled on the casing. Its main characteristic is the narrowing of the shell in the melting zone and in the tuyere zone (Fig. 9). It is understood that in principle, there is nothing against its use with hot-blast. So far, however, this cupola has been tested under cold-blast conditions. The construction of this cupola is relatively cheap and should be considered as complementary to the M.B.C. from the angle of use, that is to say, within certain limits, it is a melting plant capable of controlling between certain limits the composition of the iron through adjustment of the slag and general operation. The extent of the word *elaboration** is, however, in this case limited to the two elements C. and S., whilst the M.B.C. is a melting plant for which the term "elaboration," as already shown, extends to all the five classical elements of cast iron. Thus whilst in the case of the ADS the control is limited, it is however very exact, due to the precision with which *a priori* the composition of the slag can be regulated.

Like any other cold-blast cupola, the ADS plant does not lend itself to the reduction of the compounds P_2O_5, MnO, and SiO_2, and the term *elaboration* should be interpreted in this restrictive sense, limited to the elements S. and C. The concentration of the other elements is determined by the metal charge, and the metallic losses to be associated with the thermal and chemical conditions operating.

It is necessary to note, however, that there is an essential difference between the ADS and the basic cupola. In the latter, the erosion of the basic lining in the melting zone is an important factor in influencing the composition and the mass of the

* *Elaboration* has no exact equivalent in English. It is an all-embracing word covering everything from the weighing out of the charge to the final composition of the alloy cast.—Translator.

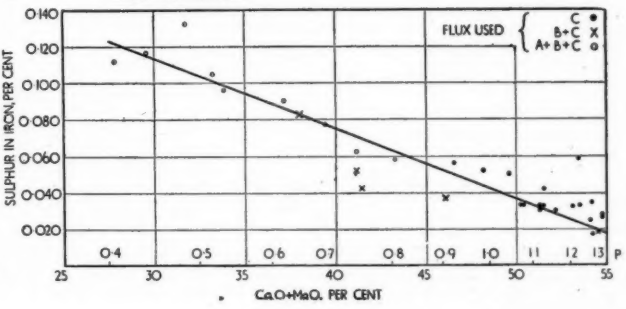


FIG. 7.—*Relation between slag and sulphur content of the iron.*

TABLE III.—*Results of Melting with a Magnesite Lining of at least 1-in. Thickness in the Melting Zone.*

Mixture.	Type of cast iron to produce.	Metal charge.				Coke.	Flux.				Carbon charged.	Carbon (actual).		
		Hem. pig-iron.	Foundry returns.	Rails.	Mild steel scrap.		Limestone.	Dolomite.	Fluorspar.	CaC_2		Min.	Max.	Aver.
1	Alloy cast-iron	25	30	25	20	15	4	1	0.5	—	2.10	3.35	3.48	3.42
2	Alloy cast-iron	15	30	25	30	15	4	1	0.5	—	1.70	3.04	3.29	3.18
3	High-carbon iron ..	—	30	—	70	16	5	1	0.75	2	1.28	3.74	3.90	3.82
4	High-carbon iron	—	—	—	100	16.5	5	1	0.75	2	0.20	3.37	3.55	3.44

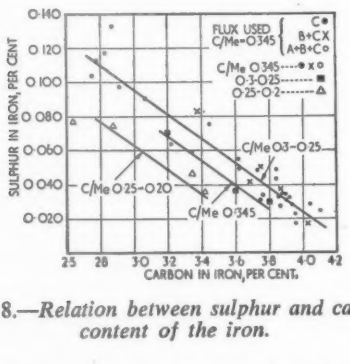


FIG. 8.—*Relation between sulphur and carbon content of the iron.*

slag. As the erosion is variable during the melting period, and as this melting is a function of thermal and chemical changes (flux additions), the close control of the composition of the slag (the chief factor in control), leaves much to be desired.

This is not the case with the ADS cupola, which, once a system of operation is established (after several runs), carries no lining in the melting zone. In this zone the casing is coated with a thin layer of surface fused lining and in the hottest part a layer of strongly oxidized and magnetic basic slag. From this, the slag both in composition and mass, that is to say, the main factor in the control of the iron can be adjusted with distinct precision.

With this metallurgical advantage, can be associated economic gains of a like order. This cupola needs no repairs to the lining of the melting zone. It allows runs to be made which are limited only by the "lifes" of the tap-hole and slag notch.

This cupola can melt every day instead of every other day, and can also operate continuously when kept warm for one or two weeks, melting each day. Keeping it hot for two weeks with nine runs of 6 to 10 tons has been successfully accomplished.

With the metallurgical and economic advantages cited, there are drawbacks which will be dealt with later.

When melting is carried out whilst keeping to a lining thickness of about one inch of basic lining in the melting zone, the drawbacks to which reference has been made no longer exist; in this case the operation of the cupola scarcely differs from that of the basic cupola having no narrowing of the shell in the melting zone. In both cases one loses the considerable economic advantages of the elimination of patching the lining in the melting zone and the possibility of working either continuously or intermittently, that is daily melting with keeping the furnace under heat.

However, it can be of advantage to carry out the melting with a lining and limit the length of melting campaign to the life of the lining, the wear of which is greatly slowed down by the efficient water cooling of the melting zone. The tests relating to this particular run are scheduled but have not yet been carried out.

I—Description of Tests

The following tests which have been carried out and are discussed, are those of the first series of some 20 melts spread over a period of two months. It is germane to point out that all these tests were carried out under commercial conditions. This means that it was necessary to make liquid iron of a predetermined composition and used for the casting of important engineering components involving rigid inspection covering composition, structure, hardness, etc.

This fact imposed a strict limitation on the freedom of the tests; moreover, as the number of casts carried out to date is not large, the early results hereafter set out are not comparable in value with those undertaken in connection with the M.B.C.

Initially, the ADS cupola had an inside diameter of 800 m.m. (32 in.) and was lined with magnesite bricks up to 1.5 m. (60 in.) above the tuyere level. In the melting zone, the thickness of the lining was 60 mm. (2½ in.). After regular and progressive wear during some four runs, the lining in the melt-

TABLE IV.—*Results of Melting without Lining in the Melting Zone.*

Mixture.	Type of cast-iron to produce.	Metal charge.				Coke.	Flux.				Carbon charged.	Carbon (actual).		
		Hem. pig-iron.	Foundry returns.	Rails.	Mild steel scrap.		Limestone.	Dolomite.	Fluorspar.	CaC_2		Min.	Max.	Aver.
5	Alloy cast-iron	15	30	25	30	15	4	1	0.5	—	1.70	2.81	3.12	3.00
6	Alloy cast-iron	15	30	25	30	15	5	1	0.5	1	1.70	2.94	3.14	3.07
7	Alloy cast-iron	25	30	25	20	15	6	1	0.5	0.5	2.10	3.10	3.17	3.12
8	Alloy cast-iron	25	30	25	20	15	6	1	0.5	0.5	2.10	3.05	3.22	3.15
9	Alloy cast-iron	30	30	25	15	15	7	1	0.75	—	2.30	3.03	3.13	3.08
10	High-carbon iron	50*	50	—	—	13	6	1	1.50	2.5	3.60	3.70	3.92	3.84

TABLE III.—*Results of Melting with a Magnesite Lining of at least 1-in. Thickness in the Melting Zone.* (*Continued.*)

Mixture.	Type of cast-iron to produce.	C Pick-up.	S Charged.	Sulphur (actual). Min.	Max.	Aver.	Difference.	Slag. $K=\frac{CaO}{SiO_2}$	$P=\frac{CaO+MgO}{SiO_2+Al_2O_3}$	Air M^3/M^3/min.	Tapping temp., true °C.	Optic Pyrom
1	Alloy cast-iron	1.32	0.055	0.050	0.057	0.053	−0.002	1.11	1.16	114	1,540	—
2	Alloy cast-iron	1.48	0.058	0.054	0.058	0.057	−0.001	1.09	1.20	114	1,525	—
3	High-carbon iron	2.54	0.057	0.025	0.031	0.028	−0.029	1.58	1.67	—	—	1,370
4	High-carbon iron	3.24	0.055	0.049	0.060	0.053	−0.002	1.52	1.55	—	—	1,350

ing zone was completely eaten away after one very troublesome melt, involving particularly oxidizing conditions. All the following are to be regarded as being made in an unlined melting zone.

II—Metallurgical Tests Reviewed

Tables III and IV include the main characteristics and the results obtained during the course of making ten runs amongst the first 20 made in a new cupola designed as is shown in Fig. 9. Table III relates to runs made with a lining in the melting zone; in every case water cooling of the outside of the casing surrounding the melting zone was in operation. The usage of water was of the order of six cubic metres per hour. Table IV covers runs devoid of lining in the fusion zone; this does not mean running on bare plate, because the latter is covered with a layer of usually highly-oxidized slag. The thickness of this protective coating, measured at the run, varies according to distance above the tuyeres. It attains its minimum (about 10 m.m. say ⅜ in.) in the area situated between the 300 and 600 levels (12 to 24 in.).

It should also be pointed out that in Tables III and IV, the make-up of the metallic charges, and the flux additions and coke, is expressed as percentages of these charges.

(*a*) *Si, Mn, P and Alloying Elements*

In Tables III and IV neither ferro-silicon and -manganese are included in the metallic charges nor are final alloying elements. Thus, no question as to the content of these elements in the iron made arises. This fact cannot be considered as an omission, as the ADS cupola is a plant designed to control the carbon and sulphur. Within certain limits, the concentration of these elements can be increased or lowered at will whilst all the other elements are subjected to metallic losses in so much as they are more oxidizable than the element iron itself. It is, nevertheless, germane to discuss this subject of melting losses, even if the results of the tests made only confirm those given in the literature of the ordinary basic cupola.

Si.—In the tests, the melting losses varied between 25 and 36 per cent. This latter figure relates to the more basic runs and those carried out under the least reducing conditions; this percentage is very high and greater than the figures given in literature. The Authors believe that it arises in part from the use of silicon-rich (75 per cent.) ferro-silicon as an addition to the charges for silicon content control.

Mn.—The melting loss varied between 10 and 15 per cent.

P.—The melting loss of the phosphorus was not controlled; if there were any it was probably negligible—the melts being neither sufficiently oxidizing nor basic.

Alloy Elements.—Chomium, the sole element more oxidizable than iron amongst those used was made as a ladle addition.

(*b*) *Carbonization*

As already has been pointed out, the test melts have been carried out during normal foundry production, that is, with definite restrictions as to the composition of the iron at the spout. Thus in every case, except for those melts 3, 4, and 10, for which there were no compositional limits, the carbon content was specified with a tolerance of + or −0.15 per cent.

In normal production the cupola should produce an alloyed engineering iron of 3.15 per cent. of carbon. This is shown to be the case for the melts set out in Tables III and IV under numbers 1, 2, 5, 6, 7, 8 and 9. Numbers 1 and 2 definitely correspond to the first and the second melts with this new cupola. As is shown in Table III the carbon obtained in the different taps of which the weights generally varied between 10 cwt. and 1 ton of iron was held between 3.35 and 3.48 per cent. with an average value of 3.42 per cent.—a value distinctly greater than the expected average of 3.15. To correct the error one can regulate either the composition of the metallic charges or the composition of the slag through flux additions.

Melt number 2 shows the result of carrying out

TABLE IV.—*Results of Melting without Lining in the Melting Zone.* (*Continued.*)

Mixture	Type of cast-iron to produce.	C pick-up.	S charged.	Sulphur (actual). Min.	Max.	Aver.	Difference.	Slag. $K=\frac{CaO}{SiO_2}$	$P=\frac{CaO+MgO}{SiO_2+Al_2O_3}$	Air M^3/M^3/min.	Tapping temp., true deg. C.
5	Alloy cast-iron	1.30	0.058	0.058	0.064	0.061	+0.003	1.07	1.10	135	1,490
6	Alloy cast-iron	1.37	0.058	0.050	0.060	0.055	−0.003	1.26	1.20	114	1,500
7	Alloy cast-iron	1.02	0.055	0.045	0.052	0.048	−0.007	1.24	1.20	114	1,500
8	Alloy cast-iron	1.05	0.055	0.051	0.059	0.055	0	1.23	1.13	114	1,480
9	Alloy cast-iron	0.78	0.054	0.047	0.059	0.055	+0.001	1.22	1.14	114	1,465
10	High-carbon iron	0.24	0.066	0.033	0.045	0.035	−0.031	1.41	1.36	114	1,490

M.B.C. and ADS Cupolas

the first method; the carbon charged was lowered from 2.10 to 1.70 per cent. and in the same order the average carbon obtained was lowered from 3.42 to 3.18 per cent., that is, quite close to the 3.15 per cent. specified. It should be pointed out that the slag is practically the same.

Influence of the Lining in the Melting Zone.

This influence is important since it can be established by comparing the results of melts 1 and 2 on the one hand with 5 and 9 on the other. First of all it is worthwhile to compare melts 2 and 5, the first with a lining of 1 in. at the end of melting, the second without lining, or more truly, with a thin layer of slag of about ¼ in. minimum thickness. These two melts are identical from the point of view of the metal charges, cokes and fluxes; the slags obtained, indices k respectively 1.09 and 1.07, are equally comparable. The conduct of melt 5 was clearly more oxidizing—the slag averaging out at 2 per cent. of FeO as against 1.5 per cent. for that of melt 2. To this correspond distinctly lower carbon contents with an average of 3 per cent. against 3.18 for melt 2. Half the taps showed a carbon content less than 3 per cent., that is to say, the lower specified limit. In the order of the test melts, 5 was the first melt without lining in the melting zone. In the following run, 6, an attempt was made to increase the carbon through the second factor, that is, slag control. As is shown in Table II the metallic charges have been maintained, but the additions of basic fluxes have been increased. The basicity index of the slag has been increased to 1.26 and with it was associated an average carbon of 3.07 per cent. and yet there was one tap with a carbon (2.94 per cent.) below the specified lower limit. The two melts 7 and 8 are identical from the angle of metallic charges, fluxes and slag sought and obtained; there they correspond with identical results from the point of view of the composition of the iron obtained. The averages of the carbon being 3.12 and 3.15 per cent. The following melts had for their object the making of an alloyed engineering iron of 3.15 per cent. of carbon ±0.15. They are shown by test 9, which had no calcium carbide amongst the fluxes charged.

As is shown by the above comparisons, the absence of lining in the melting zone limits the amount of steel in the charge added with the object of closely regulating the carbon content between ±0.15 or perhaps ±0.10 per cent.

The cause for this state of affairs should in the Authors' view be looked for in the slowing up of the melting of pieces of steel adjacent to the relatively-cool casing. At the periphery, the gases themselves are relatively "cold," and finally because of the greater speed corresponding to the maximum permeability along the length of the wall still more oxidizing. These gases licking round a piece of steel not only do not heat it sufficiently, but in the absence of a Si-rich combustible, oxidize the iron. This hypothesis is confirmed by the composition of the layer of slag adhering to the wall and by the occasional appearance of metal plates sticking to the surface of the slag wall or forming part of it.

This delayed and oxidized melting of a part of the steel charge exercises a multiple effect on the reduction of the ultimate carbon content directly by lowering the average carbonization in the solid phase and in the droplets going through the melting zone, and indirectly by increasing the FeO content of the slag and by lowering the average temperature of the slag and iron.

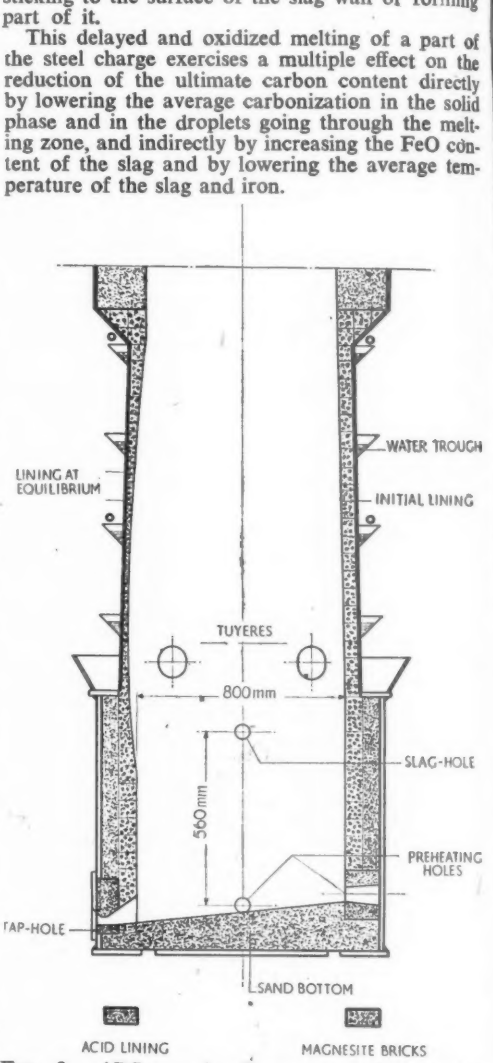


FIG. 9.—*ADS cupola (lower section), showing general construction and the nature of lining wear.*

This can be remedied by the addition of calcium carbide, but this is too costly as a fuel to warrant its use economically. Moreover, in the case of cold-blast operation, it is essential not to overdo the basicity of the slag. Thus, the part of the melting zone situated against the shell being relatively cold in excess of basic flux, frequently causes the charge to hang. This results invariably in irregular working as the slag no longer is of the

specified type. This is exactly what has happened in Test 10, where the slag actually obtained has only a basicity index *k* of 1.41 for that calculated to between 1.8 and 1.9.

Influence of Lining on "Spout" Temperature of the Iron

A comparison of the temperature of the runs at the spout showed an average lowering of the order of 40 deg. C. for melts without lining in the melting zone. It should be pointed out, however, that the melts covered by Table IV (those made with no lining) were worked whilst using exceptionally poor foundry coke. Actually it was very high-ash, friable, allowing half the pieces to pass through a 2-in. riddle.

Any conclusions should be drawn with due care, especially as later tests have not allowed the Authors to confirm this influence on the temperature at the spout. At the moment, however, they believe that the absence of lining, all things being equal, does reduce this temperature.

Desulphurization.—It is well known that extensive desulphurization at once demands basic and reducing conditions. This means that in a basic melt, desulphurization runs parallel with carbonization. In the series of test melts detailed in Tables III and IV only Nos. 3, 4 and 10 can be deemed to be melts which were clearly reducing and of medium basicity. Melt 3 with 70 per cent. steel and 0.057 S in the metallic charge yielded an average of 0.028 per cent. S. As a ratio of the S charged, this showed a reduction of 30 per cent. Such a reduction can be deemed to be normal for a slag with a basicity index of K = 1.58; an FeO content of 1.30 per cent. and a slag S content of 1.31 per cent.

In the following melt carrying a metallic charge of 100 per cent. mild steel, the desulphurization was practically zero even though the basicity of the slag was but little different (K = 1.52 as against 1.58). However, this result comes about through less reducing conditions (average carbon 3.44 as against 3.82 per cent.) and is verified by a FeO content of the slag (1.60 as against 1.30 per cent.). This corresponds to a S content of the slag of 0.96 as against 1.31 per cent. It also accounts for in part the lower temperature of the melting conditions as revealed by the difference of 20 deg. G. when read by the optical pyrometer. An analysis of this result shows very clearly that it should have sufficed to increase the percentage of melting coke in order to obtain simultaneously an increase in carbon and a lowering of the S. Finally melt 10, whilst producing a not negligible desulphurization and in agreement with the nature of the slag (k = 1.41, FeO = 0.68 to 0.90, S in the slag = 0.57) did not give the desired result. The reason should be sought in the hanging of the charge and with it in the lost efficiency of the basic portion of the fluxes not incorporated in the slag.

All the other melts (those which produce alloyed engineering iron) having an average carbon content of 3.15 per cent. gave a final S which was practically that of the metallic charge. Theoretically speaking there was no desulphurization; however, manufacture of the same type using an ordinary cupola with an acid lining gave a S. content of the order of 0.080 per cent.

It can, therefore, be seen that melting under weakly basic conditions (k about 1.20) gives an ultimate S virtually equal to that of the metallic charge; the system thus allows of the indefinite remelting of foundry returns of machine-shop scrap up 100 per cent. of the metallic charge, it being understood that there should be averaging additions of Si and Mn corresponding to the melting losses.

III—Comments

Under this heading it is proposed to recapitulate the advantages and drawbacks of the ADS cupola, whilst limiting its use as a cold-blast cupola for continuous or intermittent melting, but restricted to the case by no lining in the melting zone.

This description will thus be based on a comparison of this cupola and its operation with the ordinary acid-lined cupola and it will not take into consideration the possibility of using it as an ordinary basic cupola, whether or not water-cooled, but involving daily repair of the lining

(a) Drawbacks

1. *Loss of temperature of the iron.*—This loss of temperature due to the absence of lining in the melting zone, should be considered as a true and important disadvantage, even if it be kept at a minimum. Within the Authors' experience it can be at least partially remedied by careful methods of working by increasing the percentage of melting coke and by reducing the percentage of steel in the charges.

2. *Increase of coke consumption.*—The coke consumption in relation to the metal charge is increased from 1 to 2 per cent.

3. *Water-cooling.*—The essential cooling of the casing of the melting zone consumes a quantity of water which obviously varies with the diameter of the cupola. For a 24 in. dia. cupola this consumption is six cub. metres per hour corresponding to 2 to 2½ cub. metres per ton of iron.

4. *Limitation in the percentage of steel in the charge.*—For the production of an iron of 3.15 of carbon which is a relatively low content, the percentage of steel charged should be limited to about 40 per cent. This limitation is obviously still more severe in the case of the production of iron with higher carbon content. It is established, however, that one can increase the percentage of steel in the charges by increasing the percentage of melting coke or by using C_a C_2 additions. The interest of either the one or the other of these two methods is primarily related to the market price of steel scrap, the latter as is well known being subject to extremely wide fluctuations.

B. Advantages

1. *Lowered maintenance costs.*—The costs of the usage of refractory materials and the labour necessary for its repair after each melt are eliminated.

2. *Increase in melting capacity.*—As the furnace can be used every day, the cupola of this type can replace two. This balance is still more advantageous

because of the upkeep of the refractory in the melting zone; that is to say, the limiting factor of the time of a melt in the ordinary cupola does not enter into the question since there is no refractory in the melting zone.

3. *Possibility of maintaining under heat.*—The maintenance under heat necessitates the slagging out at the end of the melt and the retaining of the incandescent coke in the hearth of the cupola. This permits the rapid kindling next day and eliminates the operation of getting out the coke, its damping down and removal as well as the ramming of the hearth. The keeping at heat for a week or more has been shown possible in practice.

4. *Desulphurization Potential.* The possibility of desulphurization though distinctly limited in the case of weakly basic melts does allow for the remelting of foundry returns and of bought cast-iron scrap up to 100 per cent. without fear of any increase in the S content of the iron. This can easily be maintained at about 0.05 per cent. As well as the economy on the raw material aspect there is also the improved machinability shown by the castings made.

C—CONCLUSIONS

I. M.B.C. Cupola

The control potentialities in respect to the five normal elements in cast-iron are revealed in detail in the description of the results obtained. It is also interesting to note that the slag, the major factor in control, seems to operate not only because of its ultimate analyses, but also through the nature of the fluxes used. This is most probably in accord with the way and temperature of the formation of the slag, but the explanation of the phenomena would require a special research.

It should be pointed out, however, that the results found in this work are not strictly applicable to other conditions of operation, either to M.B.C. plants of different sizes or to different blowing conditions, etc.

II. ADS Cupola

If this cupola be compared when operating without lining in the melting zone (that is the sole method which has so far been studied in any detail) first with the M.B.C. and then with the ordinary cupola, it will be seen that it lies between the two. It is, therefore, an "*elaboration*" apparatus whilst the ordinary cupola is a simple remelting plant. However, the "elaboration" factor is limited to the elements C and S, whilst in the M.B.C. it is extended to all the five normal elements of cast-iron. It is thus apparent that the ADS is complementary to the M.B.C. plant. It is too early to speak of its potentialities at a time when the tests are only just beginning, but it does appear that they are of interest for the manufacture of engineering quality castings, especially in countries paying high wages, if only because of the much reduced upkeep costs.

Finally, the Authors thank Fabrimetal and their collaborating associations, I.R.S.I.A. and C.R.I.F. for sponsoring the researches undertaken.

REFERENCES

[1] Metallurgical Blast Cupola.

[2] A type of Cupola developed by the *Centre d'Etudes et Recherches en Fonderie*, under the direction of Professor A. De Sy.

[3] Metallurgical Blast Cupola by R. Doat and M. A. de Bock—Belgian Exchange Paper to the International Congress held at Atlantic City, USA.

DISCUSSION

When the Paper was presented in London, MR. R. I. HIGGINS asked a question concerning the accuracy of the analytical estimations carried out on the slags. Did the Authors believe that their analyses for silica in the slag were sufficiently accurate to draw a distinction between the silica content of the slag of 31.6 per cent. and a corrected silica content—whatever that might mean (and he had to confess that the significance of "corrected silica" quite escaped him)—of 30.9 per cent., and similarly all down the columns of Table I? The differences between the two appeared to be well within analytical error.

PROFESSOR DE SY, in reply, said the corrected silica figure was only a calculation. One could express the silica percentage in two ways: first, as a weight percentage, which was the normal way, but also when one made an analysis of the silica in terms of weight and one had, say, 30 per cent. of SiO_2. Then one took the calcium-oxide content and the magnesium-oxide content and put in the calcium plus 1.4 times the magnesium-oxide (which was the calcium exchange-equivalent, as it was called), and the percentage of silicon to the sum of the elements present with that corrected calcium equivalent was the meaning of the corrected silica.

As to the accuracy of the silica analyses in the slag, such estimations were indeed very difficult and from personal experience he had found that when he gave slag for analysis by two or three different laboratories in Belgium there was usually a considerable difference between the results.

A MEMBER asked whether the M.B.C. cupola was sensitive to variations in coke size.

PROFESSOR DE SY replied that it depended, of course, on the type of M.B.C. cupola, namely the diameter. He personally had not very much experience with industrial M.B.C. cupolas and only knew them as a result of metallurgical researches on the small type, but there were others present who could probably supply the information.

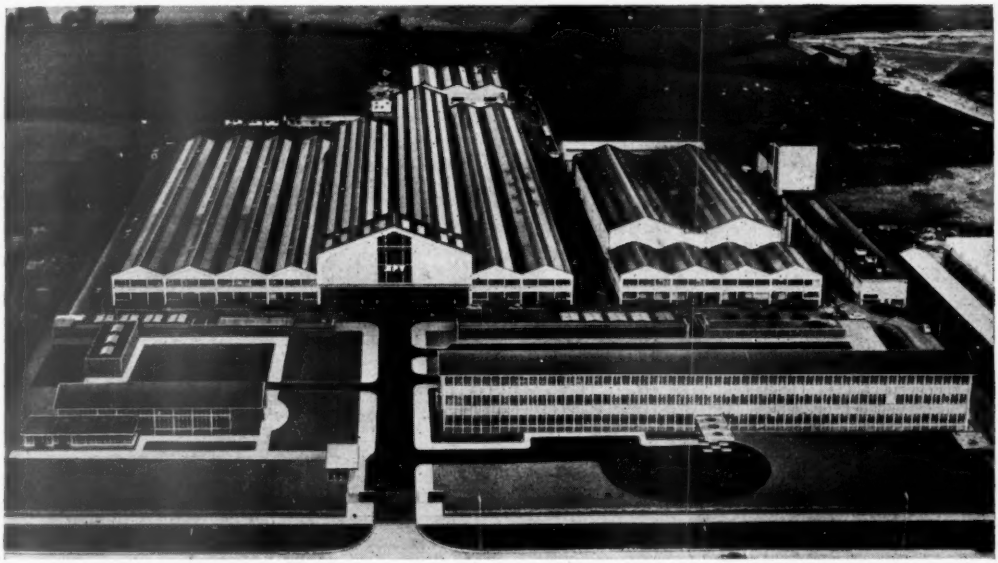
MR. ROGER BALON, elaborating the reply, said an effort was to be made to select the dimensions of the pieces of coke to suit the diameter of the M.B.C. cupola.

On the motion of the CHAIRMAN (MR. J. BLAKISTON), a hearty vote of thanks was accorded to Professor de Sy and his colleagues for their Paper, and the proceedings then terminated.

APV Move in its Final Stages

The final stage in the transfer of the A.P.V. Company, Limited, to their new works at Crawley, Sussex, will be completed towards the end of December, when the administrative, sales, technical and drawing office staff move into the new block of offices. The laboratories moved during November. The company commenced the transfer of the four works in London and Slough towards the end of 1952; the operation was organized in three stages —first the engineering division and the foundries of A.P.V.-Paramount, Limited, then the fabrication division and now finally the administration and staff.

This represents an unusually complex and complete removal of an industrial unit, for most of the 2,000 personnel now employed at Crawley have been transferred from London. They have been provided with houses in the Crawley New Town whenever required. At the completion, the company will be accommodated in an entirely new factory shown in the illustration below—one of the most modern of its kind in this country. From December 24, all communications should be addressed to A.P.V. Company, Limited, Manor Royal, Crawley, Sussex (telephone: Crawley 1360), except those for the chemical-engineering department, which will be accommodated, together with the company's London office, at an address which will be announced later.



ICI Titanium Factory

A factory for the fabrication of titanium is to be built by Imperial Chemical Industries, Limited, near its existing works at Waunarlwydd, Swansea. Work will begin as soon as possible and it is hoped that the new factory, which will cost about £2,000,000 and employ some 250 people, will be in production in 1958.

Considerable pioneer research and development work by ICI has culminated this year in the commissioning of two large-scale plants for the production of titanium and its alloys. The first of these, built by the company's general chemicals division at Wilton (Yorks), is concerned with the extraction of metallic titanium and can produce 1,500 tons of raw titanium a year. The second, at the Kynoch Works of the metals division in Birmingham, is responsible for melting granular titanium produced at Wilton, and forging it into slabs and bars for further fabrication.

Some fabrication into wrought forms—sheet, strip, plate, rod, tube, and wire—is at present being carried out at the Kynoch Works and in other factories of the metals division, including the Landore and Waunarlwydd works in South Wales.

Shaw Processes Agreements

Shaw Processes, Limited, of 25, Clyde Vale, Dartmouth Road, Forest Hill, London, and 41, Carliol Street, Newcastle-upon-Tyne, announce that they have recently concluded arrangements with Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, whereby Shaw Processes, Limited, now have the exclusive right to arrange sub-licence agreements relative to the Investment-X process of precision casting. This method of moulding, basically a lost-wax process, effects very considerable simplification and economies in that process and is applicable to castings of much larger size than is normally possible by lost-wax methods. The process is protected by patents both issued and pending throughout the world.

Agreement has also been reached with British Industries Corporation of New York, for the immediate establishment of a company to be named the Shaw Processes Development Corporation Inc. which will establish demonstration plant and a laboratory at Long Island, and will exploit the Shaw process of precision casting by the granting of licences throughout the United States and Canada.

Notes from the Branches

Newcastle-upon-Tyne

A very interesting and informative meeting of the Newcastle-upon-Tyne branch of the Institute of British Foundrymen was held at the Neville Hall on November 12, at which Mr. G. E. Parramore of Imperial Chemical Industries, Limited, presented a paper on the CO_2 Process. The fact that over 100 members and visitors were present—a record attendance for this branch—is a clear indication of the interest shown in this relatively new Process. Mr. C. Nicholls, the branch president, was in the chair and introduced Mr. Parramore.

As is well known by readers of the JOURNAL the CO_2 Process of preparing moulds is essentially one in which the facing sand is a dry sand mixed with sodium silicate, and when a mould has been formed, either before or after the pattern has been withdrawn, CO_2 is blown through the treated facing sand. The chemical action resulting converts the prepared sand into a hard and strong mass and the mould thus prepared, which may or may not be given a spirit wash, is completed for casting.

Mr. Parramore discussed the Process under four main headings: commencing with a brief résumé of the history of the Process, following with the materials involved, the techniques employed, and, finally, the equipment necessary. In some respects the Process is comparable with shell moulding without the need for heat, but it has much wider application. One of its great advantages is that it can be applied to reduce the need for the normal dry-sand and loam moulding methods.

The sands preferred for the Process are those with a low-clay content and the grain-size should be such as to provide a permeable mass through which the CO_2 can be forced under pressure. Many suitable sands were mentioned, but in the North-East area Carew sand seems to predominate. The dried sand is mixed with 4 to 4.5 per cent. of sodium silicate, if for iron castings pitch pellets may also be added. The time of mixing should be carefully controlled as the mixture tends to deteriorate with over-milling. Flat ramming of this sand mixture is preferred and it may be swept or strickled to shape.

The procedure of mould making is very similar to orthodox methods excepting that facilities must be provided for CO_2 to permeate the mass. (Several types of flexible perforated tubing, which are rammed up in moulds for this purpose, were exhibited and also shown on a screen.) The moulds are covered before applying the CO_2 and the time during which the gas is applied will vary according to the bulk of the sand to be treated and its permeability from about 50 or 60 sec. to 5 min. It is important that the pressure of the gas is sufficient to exhaust all air from the mould; for this purpose a pressure of 25 lb. per sq. in. is usually employed. Typical examples of moulds prepared by this Process, as well as cores, were shown on a screen. They covered a wide range from very small moulds, which are assembled for gassing, to an oil engine bedplate mould made in the foundry floor which, normally, would have been prepared by the dry-sand method of moulding.

Mr. Parramore discussed the form of equipment for storing the carbon dioxide, either in liquid or solid form, and for supplying moulds with the gas.

When the meeting was thrown open for general discussion it was apparent that many members present were operating the Process and while many questions were asked the lecturer received considerable support from the body of the hall in answering them. As with any major development of this character teething troubles were encountered and Mr. Parramore was the first to admit that experimental work was still in progress to overcome problems, but the progress so far achieved and the economy effected indicated a great future for the Process. An excellent meeting ended with a very cordial vote of thanks to the Author for his courtesy in presenting the paper.

Electrical Development in India

Ambitious and imaginative plans by India to raise the standard of living of her population are expected to bring about an ever-increasing demand for electrical equipment, according to Lord Chandos, chairman of Associated Electrical Industries, Limited, which has been appointed to act as consultants in a major project to create a heavy electrical manufacturing industry in India. It is the intention of the Indian Government to build up an independent industry capable of meeting a substantial proportion of the country's requirements for hydro-electric plant, electric traction equipment, generating plant, and distribution gear. A factory of the size envisaged is expected to employ about 10,000 people and the capital cost of such a project is likely to be as much as £20,000,000.

AEI has been appointed for a basic period of 15 years and will act as consultants in the design, layout, and construction of the factory, the general arrangements and procurement of plant, machines, and equipment, and the preparation of a training scheme. It will provide in India a resident engineer and the necessary technical specialists and a number of the group's experts will be leaving shortly to survey suitable factory sites.

Companies of AEI have operated independently in India since the beginning of the century and the products of the new Government plant will not conflict with those manufactured by the existing factory.

Iron-ore Imports

Iron-ore imports in October, and the total for the first 10 months of this year compared with the corresponding period of 1954, are shown below.

From	Month ended Oct. 31.	Ten months ended October 31.	
	1955.	1954.	1955.
	Tons.	Tons.	Tons.
Sierra Leone	62,055	502,557	557,254
Canada	265,133	821,940	1,135,559
Other Commonwealth countries and Eire	901	33,746	12,305
Sweden	397,939	3,509,644	3,302,871
France	58,897	370,754	533,305
Spain	64,661	416,865	685,126
Algeria	160,546	1,803,331	1,877,506
Tunisia	123,308	514,249	708,940
French Morocco	8,800	220,418	208,516
French West Africa	39,499	483,649	413,536
Spanish Morocco	13,350	222,208	173,984
Liberia	29,220	188,870	250,481
Brazil	72,298	377,374	429,210
Other foreign countries	93,390	307,911	404,170
TOTAL	1,389,997	9,773,516	10,692,763

W. H. ALLEN SONS & COMPANY, LIMITED—Mr. Tom Golding and Mr. Arthur Holman Hooke have been appointed additional directors.

Further Excerpts from the Correspondence of a XIXth Century Ironfounder

By T. R. Harris

In a previous article some extracts from the correspondence of a nineteenth-century ironfounder were given, showing something of the state of ironfounding in Cornwall up to the middle of the century. The following excerpts, from the same collection, deal with the latter half of the century and give a picture of changing conditions in the foundry.*

During the Crimean war, the founder was approached with a view of supplying armaments and replied in November, 1854: "We are not makers of cannon shot or shell, having no appliances for this. We are extensive iron and brass founders for all kinds of machines for marine and land purposes."

In the following year, the manufacture of mortars was undertaken, and after initial experiments a satisfactory technique evolved. "We are," he wrote in September, 1855, "entirely satisfied with the new mode of casting adopted with the two mortars. The head of one cut off yesterday morning is sound and is boring well . . . we have no doubt of being able to greatly facilitate the completion of this order."

Drum-type Castings

Writing, in September, 1867, to the Dowlais Iron Company, which firm had ordered five large spiral drums from the foundry, the founder remarked "With regards to finish we may remark that we will be careful in casting, but you must not expect finish as if turned, neither can we consent to have them rejected for a slight fault."

Castings for large winding-drums occasionally gave trouble, especially when the design was not suitable for castings as the following extract of October, 1871, illustrates. "We have had some trouble casting your cast-iron plates c.c. for drums. They break in shrinkage, as shown by red lines on tracing, although we took every precaution and used best No. 1 Welsh iron. Would you, therefore, have any objection to our dividing the annular plate from point AA to point BB on tracing, and after casting driving in a wedge double dove-tailed piece at S, as shown. We think by so doing there would be no danger from shrinking."

Heavy castings often necessitated a special technique and quoting for some work in 1872, the founder wrote: "We think the retorts should be cast with a *high head* to ensure soundness, then by using carefully selected iron you would no doubt secure sound castings. The price will be £22 per ton, for as we propose to make the retorts we should, by casting a high head, waste one third of the actual weight of each casting."

Later in the year, in reply to a request for information as to the delivery of the casting, it was said, "We have had to make preparations for casting the retorts as special apparatus is required. We hope to get the whole finished in about 8 weeks."

Choice of Work

Although at the beginning of the century the founder would undertake all types of castings, including gas pipes and church bells, later these jobs were being declined. "We do not," he wrote in 1872, "manufacture gas pipes, for they can be produced by the makers of pig-iron cheaper than we could make them here from second melting of the iron." Some four years earlier he also stated "We do not think that we could cast bells nearly so well as those founders who make it a special branch of business."

The quality of pig-iron was occasionally complained of, as in July, 1867. On this occasion the founder wrote, "We regret having to inform you that the pig-iron shipped by you to us since March month is of a mixed and inferior quality. Two engine beams weighing 15 tons each have been cast from the iron, the first after lying in our yard a month was *drawn assunder;* the fracture is bad. We have been compelled to discard the use of the iron and to order a supply of another maker. The loss to us is very serious, both in money and time, being under penalty for time as well as the expense of the second casting. We advise that you will send a competent agent here to investigate this affair; it is to us a very serious affair and we desire to come to an understanding at once."

Testing Procedure

Tests were sometimes made of pig-iron, and the report of such a test was forwarded to the supplier in September, 1871. "We have," it was reported, "tried some with ½ scrap and 2 cast from the pig without any mixture. The bars were 4-ft. long and 1-in. square." The first bar from clean pig broke with 5 cwt. 1 qr. 6 lb. and the second, 4 cwt., while the bars made of ½ scrap broke at 4 cwt. 3 qr. 16 lb.; 6 cwt. 1 qr. 0 lb.; and 5 cwt. 3 qr. 2 lb. "We are not," continued the report, "quite satisfied with the clean pig. You will observe that the second bar from your pig broke with a small load, but we are not satisfied with the experiment. The strength of the first bar is not quite up to what I had expected."

Apparently the supplier of the iron wrote asking for particulars of the method of testing the bars, for in October the founder writes "We try them in bars 1-in. square, 3 ft. 11 in. between supports, resting on iron horses, the weight suspended in the centre in a

* Printed in the JOURNAL, January 24, 1952.

Correspondence of a XIXth Century Ironfounder

single scales with knife edge bearing thus:"—(then followed a small sketch).

In January 1872, the founder acknowledges the results of some tests carried out by the ironmaster. "The results you have obtained respecting the trial of your cast iron is very good. A tensile [transverse] strength of 14,000 lb. is a good average and the deflection ½ inch so far superior to anything of which I have experienced. The tensile strength of 22,000 lb. per square inch is very high indeed."

Analysis Considered

In the late 'eighties the foundry was reorganized by a younger member of the firm, who was keen on improving the products of the foundry. In November, 1888, he writes: "The recent lot of pigs you supplied us with were, we believe, of No. 2 quality. We do not know the analysis of the pig but they suit us pretty well, the only objection being that the runners or the sows, of which there was a fair proportion, did not appear of such uniform good quality as the pig itself. Probably they had the last of the charge from the furnace. A selection, as you now suggest, would overcome all the difficulty. We do not care for too much silicon as we think it makes the iron "rash," of course, of sulphur and phosphorus the less the better."

In June, 1889, information is sought "respecting the brands of iron generally used for malleable casting. We had had under discussion the advisability of going in for malleable casting or steel, and will ultimately go in for steel, in which case we shall be troubling you for some of your renowned hematite brands."

Later, in September, he wrote "It would be to our mutual advantage if you could spare us 160 tons of your No. 1 hematite pig exactly as previously supplied. I may say that for many years this brand was considered here as being too rash and altogether useless for our purpose. I find that the cause of failure has not been the fault of the pig and we are now using it with success. I should now be very sorry to have to discontinue the use of the iron or make further experiments with another firm until you can get exactly the quality suitable to us."

Steel-mix Iron

—The mixture evolved was a type since referred to as "semi-steel" or later "steel-mix iron" and was to enable certain castings to be made of thinner section to facilitate transport. Writing to South Africa in June 1889, he says *inter alia*: "The pump bottom we have now designed especially for your requirements are as light as possible and we are casting them of a special steel mixture of our own. This applies to all work we are making for you."

Later in the year the following report was sent to the London office of the firm: "We are advised that we have the run of the Transvaal pump work and hope this may continue. We are keeping this department hard at it, but the steel mixture we are casting the pump work in is rather difficult to manipulate and we get a greater percentage of wasters than in cast iron. We have with the steel mixture been able to reduce the weight of our work enormously."

Answering an enquiry for a steel casting, it was said: "We do not cast steel by the crucible or Siemens Martin principle, but what we cast is a mixture of our own which contains a very large percentage of pure steel and is very considerably stronger and tougher than cast iron. . . ."

New Catalogues

Mechanical Draught. In publication No. SF299, Davidson & Company, Limited, Sirocco Engineering Works, Belfast, give particulars of various designs available to meet the requirements of both large and smaller industrial boiler-houses.

Silicon-carbide Refractories. In leaflet RD63, Morgan Refractories, Limited, Neston, Wirral, Cheshire, illustrate and describe a wide range of heat-resisting and slag-corrosion-resisting refractories made from silicon carbide. It is available on writing either to Neston or Battersea Church Road, London, S.W.11.

Mobile Cranes. In publication No. 494, Ransomes and Rapier Limited, Waterside Works, Ipswich, illustrate and describe their 6 and 7 standard mobile cranes, which are used for handling loads up to 6 and 7½ tons respectively. Good use has been made of close-ups with lines pointing to captions to emphasize the outstanding pictures.

Shell Coreblowers. The Shallway Corporation, South Fourth Street, Connesville, Pa., USA, have issued a leaflet which describes and illustrates a range of six coreblowers catering for three sizes of cores, the smallest being 6 by 12 by 10 in. and the largest 12 by 18 by 36 in. high. With it there were two leaflets showing the types of cores now in production.

Control of Mechanical Handling Plant. Publication No. 1766 issued by Allen West and Company, Limited, of Brighton 7, is a six-page folder which by illustrations and captions shows many installations, the control gear for which is made by this company. Whilst coal and coke conveyors appear, there is no picture of a foundry application.

Distribution Switchgear. The Lancashire Dynamo Switchgear, Limited, St. Stephen's House, Victoria Embankment, London, S.W.1, in list LS30, describe and illustrate with a wealth of technical data a wide range of metal-clad switchgear. It is a 24-page booklet and is of the type one automatically adds to the reference library of trade literature.

Dust-extraction and Collection. Present conditions are such that foundrymen cannot have too much data on this important subject. An interesting contribution to the dust-removal problem is made in a publication issued by the air conditioning division of Mancuna Engineering, Limited, Denton, Manchester. Whilst no specific instances are given of foundry applications, the firm has obviously carried out some man-size jobs. The pamphlet certainly gives the impression that the firm does make a high-grade technical approach to the problems they encounter. This brochure—full of interest—is available to readers on writing to Denton.

Chemical Reactions in the Cupola*

Discussion of the Congress Paper by H. Jungbluth and K. Stockkamp.

This report of the Congress session when the German Exchange Paper was presented begins with a lengthy summary by the Authors, during which some new data were given. In discussion, there was comment from a German colleague of the Authors and extensive criticism from a British source—mainly that the theoretical basis laid down for the cupola reactions was capable of very limited extension to actual cupola practice. Another speaker suggested an oil burner might be incorporated to advantage in the blast supply of a cupola. The use for a cupola of hot blast supplied from a blast furnace was also mentioned. The final contribution concerned the Esslinger process.

When the Authors, in person, presented the Paper under the above title to the International Foundry Congress in London, they introduced it in the following terms:—

It has been scientific practice to apply mathematical methods to the analysis of metallurgical reactions for the past 25 or 30 years, although their use in industry has been limited to a few firms with well-trained metallurgical staff. In the case of the cupola, up to the present there have only been beginings; in this connection special reference must be made to the work of Fleming[30] on the subject.

In the first part of the Paper, a short explanation is given of the mathematical procedure, the fundamental theory of which can be found, of course, in any modern textbook on physical chemistry. In particular, however, the simplified treatment applied by H. Ulich has been applied. In principle, it is a question whether the "driving force" of the reaction is solely a function of the heat of reaction—as Thomsen and Berthelot still think—or whether it is also related to a second quantity, that is, to entropy, which in its turn, is related to temperature. The first term of the equation to be constructed is decided, in the case of sufficiently low temperatures, by the direction of the course of the reaction, *viz.*, the degree of heat, and for this extreme case the Thomsen-Berthelot principle is valid—that exothermic processes precede endothermic and the more so the greater the heat liberated. This to-day is generally represented by negative values, as it is in the Paper. In the case of sufficiently high temperatures, however, the contrary is true; the second term is governed by entropy, the procedure only valid, it is true, if it differs from nil. Since many numerical values, as, for example, the temperature relationships of specific heat, or even the heat of reaction, are not always very accurately known, considerable simplifications of the method are permissible, as Ulrich has shown, and do not conflict too greatly with observations. Moreover, the calculations relate to the fundamental enthalpy of the reaction only.

Systematic Examination

Next, the behaviour of iron oxide, silicon, manganese and sulphur is analysed mathematically. Here are presented in collected form, for the cupola, researches which have been partly set out elsewhere. It could be shown that iron oxide Fe_2O_3 cannot be stable in the cupola, since, as Schenk and Fleming have calculated, a ratio of $CO:CO_2$ of 1:8,000 to 1:10,000 is still enough to reduce Fe_2O_3 to Fe_3O_4 through the CO, and that a further reduction to FeO is easily possible. FeO, on the contrary, cannot be reduced by the CO in the cupola shaft, since the CO concentration required for this is about 23 per cent., which is not available in a standard cold-blast (atmospheric air) cupola, in which, actually, it is quite wrong to aim at low-CO content. On the other hand, a reduction of FeO in the hearth is possible as the result of stable carbon, especially with increasing temperature, in spite of the endothermic character of the reaction, since in this case the value for entropy is determined for a higher temperature by the marked expansion of the gaseous phase.

(Here the Authors exhibited a series of slides including new Figs. A** and B together with others taken from the Paper, describing them by the text which follows.)

Silicon is not reducible by CO in the cupola shaft, because in such a case the necessary degree of concentration of carbon monoxide cannot be obtained. On the other hand, a reduction is possible of silicon from silicates in the slag, iron or carbon respectively. Fig. A shows the temperature relationship of the logarithm of the equilibrium constant of the reduction of iron oxide by means of carbon, and of silica by means of iron. The logarithm of the equilibrium constant for silica reduction through carbon must be the sum of both logarithms. Fig. A reproduces a curve for the log. of the equilibrium constant of silica reduction by iron which has been freshly calculated for this summary, because the values given in the work of Körber and Oelson evidently apply to weights of concentrations, the silica having been reduced in the equilibrium constant, while molar concentrations have been used for the two other constants. Above 1,825 deg. K., the reduction of silica by carbon proceeds spontaneously. From Fig. A it can be seen how important a low FeO content in the slag is in this connection. During the reduction of silica there is, of course,

* Paper printed in the JOURNAL, October 6 and 13.

** Illustrations reproduced on p. 647.

a simultaneous decrease in the carbon content of the iron. However, since excess coke is present, the carbon content of the iron can be restored again forthwith, to the extent that occasionally it is compatible with the silicon content of the iron.

Manganous oxide, also, cannot be reduced in the cupola shaft by CO, because the partial pressure of CO required is unobtainable; however, as the result of stable carbon in the hearth, at temperatures above 1,700 deg. K. a valid value is determined in Fig. A.

Sulphur cannot be removed in the quantities usual in the normal cupola, or in the hot-blast cupola, because with increasing temperature the capacity of even manganese to desulphurize decreases, as Durrer has established. On the contrary, the process is rather a distribution of iron sulphide throughout the slag and the melt, according to Nernst's law of distribution. Desulphurization can then be effected by quicklime, whereby the sulphur remains bound to calcium. This is possible, however, only if the FeO content of the slag remains low. It is again a secondary, cooperative reaction, and it can be seen immediately from Fig. B how important a low FeO content is. According to Durrer, Hellbrügge, and Marinček, desulphurization by acid slags appears to be possible if the operating temperature is sufficiently high, *i.e.*, when the slag is fluid, and as a result the sulphur is soluble in it.

Second Part

In the second part of the Paper are reported results which have been obtained with a hot-blast and acid-lined cupola. The furnace was operated according to a "free-hearth" method, by which a constant depth of slag of 250 mm., was maintained in the furnace by means of a syphon arrangement. It is not to be expected, of course, that perfect numerical agreement with theoretical values will be found, since concentration and pressure did not comply with fundamental theory. Besides, scatter in values was to be expected, since this always occurs in investigations of the criteria under discussion, and can only be adjusted by accumulating research data and drawing curves for mean values. Such an examination is being borne in mind. Nevertheless, qualitative agreement could certainly now be expected.

Next, it could be established that in the case of otherwise constant conditions, the greater the CO content of the flue-gas with increasing blast temperature, the smaller will be η_v. The iron temperature as a result rises; so that in the case of uniform conditions, the CO content is immediately an indication of the extent of the temperature zone, in the furnace. The so-called thermal efficiency of the furnace falls, it is true—a penalty exacted in return for higher iron temperature. Both conditions are represented in Fig. 14. The FeO content of the slag falls with rising iron temperature, which in its turn depends upon blast temperature, with rising coke charges, *i.e.*, with decreasing η_v or with increasing CO content. Decreasing FeO content of the slag goes hand in hand with decreasing FeO in the iron (Fig. 15 on account of Nernst's law of distribution. With rising iron temperature caused by hot blast, silicon loss decreases and changes to silicon pick-up (Fig. 17). Of course, a corresponding silica content in the slag is necessary for the purpose. In the case under consideration the ratio $CaO:SiO_2$ was about 0.7. If it is increased, the degree of silicon reduction becomes less and *vice versa*. (Fig. 22); Fig. 18 is therefore interesting because it shows how pick-up of silicon by iron takes place with completely constant charges but variable temperature of hot blast. It was possible to see from Fig. A how the silica reduction was markedly influenced by the FeO content of the slag so that high rate of reduction presupposed low FeO-content and *vice versa*; Fig. 21 confirms these facts.

Also, the theories which have been proposed with reference to desulphurization by acid slags are confirmed in their entirety; that is, that with increasing temperatures of blast, iron and slag, desulphurization becomes better because the solubility of sulphur is greater in slags at high temperatures.

The present investigation is the beginning of a larger systematic research which has been put in hand by a group formed to study the hot-blast cupola. (*Arbeitsgemeinschaft zum Studium des Heisswindkupolofens.*) A new cupola installation is being set up at Wetzlar which will be devoted exclusively to research, and which will have all the necessary arrangements for this purpose. In particular, a new water-cooling system at about 200 deg. C. will be used for it, and should produce, it is expected, much more uniform operating conditions. (Illustrations were shown here of Steinmüller hot-blast cupola plant, one as installed in this country (*vide* JOURNAL, July 23, 1953, p. 119, Fig. 1), and the second the experimental plant at Wetzlar. An example taken from the automatic recorder of blast pressure, volume, and temperature for a hot-blast cupola plant was also shown.)

Acknowledgment

The Authors concluded their introduction by stating that it should be added that owing to an oversight an acknowledgment which was due had been omitted from the English text. The omission concerned Buderus'sche Eisenwerke at Wetzlar, their technical director, Dr. F. Grosser, and the A.S.H.; these had sponsored the work and provided facilities for carrying it out. It was rare for a cupola installation to be available solely for scientific research, as had been the case reported on in their Paper.

The Chairman (Mr. J. Blakiston and Dr. G. Schwietzke, jointly) then opened the meeting for discussion, the first comment being a written con-

tribution from Dr. Zeil, who was in fact present at the Congress.

Temperatures and Locations of Reactions

DR. W. ZEIL, Karlsruhe, wrote that an important section of the work done by Jungbluth and Stockkamp concerned the influence of temperature upon the pick-up and loss of silicon from the metal in the cupola. It had been shown without doubt that with an increase in temperature the possibility of a pick-up of silicon from the slag to the metal was enhanced. The experiments undertaken confirmed this. In the thermodynamic treatment of this problem, as the Authors had pointed out, one could only be concerned with the fundamental reaction energy on the assumption that the reactants were in a standard state at the start of the reaction. In the cupola, this was demonstrably not the case in practice.

In order to apply these relationships to the questions involved in cupola operation, it was necessary to know the location of the reaction in the cupola. From Fig. 23 of the work under discussion, it was

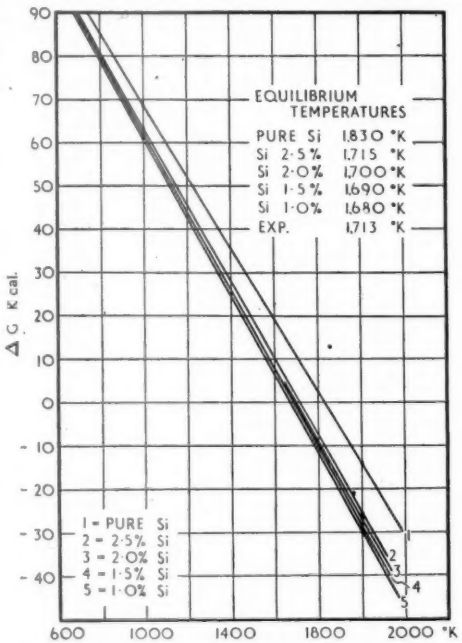


FIG. C.—*Variation of free energy, with temperature, for the reaction* $SiO_2 + 2C \rightleftharpoons Si + 2CO$. *(Zeil.)*

evident that the magnitude of silicon pick-up was closely dependent upon the depth of the slag. This indicated that the reaction between the free SiO_2 of the slag and the carbon dissolved in the iron took place as the drops of iron passed down through the slag layer. The writer proposed the following assumption: The iron was saturated with carbon and the slag was saturated with SiO_2. During the reaction, an envelope of pure CO gas was formed around each drop of iron. The question now arose: At what temperatures could silicon pick-up be expected to occur for different levels of silicon content in the iron? For this one could make use—along with the fundamental reaction energy—of the so-called residual reaction energy which was given by R.T ln x_i (x is the molar fraction). This expression was negative in the case of consumed material and positive for material produced. In the example, in accordance with the conditions pre-supposed, the molar fractions of C, SiO_2 and CO equalled 1, and so this residual energy disappeared. It only remained, therefore, to calculate the residual energy for the silicon. The results of the calculation of the free-enthalpy ΔG for the reaction $SiO_2 + 2C = Si + 2CO$, worked out by consideration of residual energy, were to be seen in Fig. C. The latter illustrated at what temperature in deg. K the value of ΔG became zero for different levels of silicon concentration; that is to say, the temperatures above which silicon pick-up might be expected to occur for a pig-iron of a given silicon content. According to Fig. 17 in Jungbluth and Stockkamp's Paper, the temperature above which silicon pick-up did take place was 1,713 deg. C. On the assumption that this referred to a normal-grade iron carrying some 2½ per cent. silicon it was evident that there was good agreement between this and the temperature predicted by the writer's calculation.

Another of the Authors' diagrams supported the theoretical treatment of the problem as here proposed. Fig. 19 showed that with a blast temperature of 200 deg. C., silicon pick-up began with an iron carrying 2.45 per cent. Si, while, if the iron carried 2.85 per cent. Si then the pick-up of silicon did not start until the blast temperature had been raised to 280 deg. C.

From Fig. 12, it was evident that a variation in the blast temperature of 80 deg. C. caused an average variation in the iron temperature—and this was readily calculable for the writer's reaction—of 20 to 30 deg. C. This difference in temperature corresponded, according to the present calculations, with difference in silicon content amounting to 0.4 per cent. The fact that this figure had been found to be the right one in the experiments carried out by Jungbluth and Stockkamp on their hot-blast cupola, *i.e.*, that the agreement between theory and practice was remarkably close, was a further indication of the correctness of the proposed mechanism accounting for silicon loss and silicon pick-up in the cupola.

ORAL DISCUSSION

Mr. R. I. Higgins, B.SC. (British Cast Iron Research Association) said the second part of the Paper formed a very valuable contribution to literature on hot-blast cupolas and the Authors deserved great credit for the enterprising practical experiments carried out. The physical chemistry of cupola melting was very little understood by foundrymen, who should benefit considerably by

the results obtained and by the demonstration that they can be assembled in a rational framework. The validity of the theoretical study of the chemical reactions in the cupola, given in the first part of the Paper must, however, be accepted with some degree of reservation and his next comments were concerned solely with this theoretical aspect and should not be interpreted as a criticism of the experimental work.

As it stands, the first part of the Paper could be misleading, particularly if one accepted it as a theoretical study of the *actual* chemical reactions in the cupola. In the case of the very important reactions involving the reduction of silica and manganese oxide by carbon, those involving pure metals and pure oxides had been considered, but such reactions did not adequately represent events which might take place in the cupola well. The reactions taking place in the cupola well generally involved metal, slag and coke. Silica and manganese oxide were dissolved in the slag and as a result might behave differently from the pure compounds. Similarly, silicon and manganese, the products of the reduction reaction, were dissolved in the metal and for this reason behaved other than as pure elements. The state of the reactants and resultants was fundamental to the theoretical consideration of reactions in the cupola and wrong assumptions concerning such states might lead subsequently to grave errors.

Inconsistencies

The section entitled "Methods of Calculation" should be useful for the reader who was unfamiliar with thermodynamic manipulations. It was to be regretted, therefore, that a number of inconsistencies appeared in this section of the Preprint of the Paper. How far these inconsistencies had arisen during translation or how far they were due to errors in reproduction was uncertain, but it was appropriate that they should be drawn to the Authors' attention:—

(1) In explaining equation 1 (*a*), *i.e.*, the formal expression of the standard free-energy change for a reaction, the Authors stated, in the same sentence, that it applied for "a partial pressure of 1 in the gas phase" and "correspondingly (when) the pressure is one atmosphere total." Clearly, both conditions could not apply except in the very special case where only one type of gaseous species was involved in the reaction.

(2) In discussing the second approximation which could be made for the purpose of integrating equation (3) the text read "it is assumed that the variation of specific heat during the reaction is directly dependent on temperature" but their equation $\Sigma \nu_i \times C_{pi} = \text{constant} = a$, showed it as independent of temperature.

(3) At the end of the section dealing with methods of calculation, it was stated "It must be pointed out, however, that the 'reaction energy' which has been evaluated by these methods is that under ideal conditions (ΔG_0), *i.e.*, with the solid reactants in the pure state and at a partial pressure of one in the gaseous phase, with T always equal to 298 deg. Abs." Later on in the text, however, Tables I to VIII showed values for ΔG_0 for temperatures ranging from 800 to 2,000 deg. Abs. This could be very perplexing. Incidentally, the terms ΔH_0 and ΔS_0 evaluated in Tables I to VIII were not defined by equation 1 (*a*), and this could be equally perplexing for the person who had no ready access to Ulich's textbook.

In the section dealing with the behaviour of iron oxide in the cupola, the Authors had summarized their thermodynamic findings for the reaction $FeO + CO \rightleftharpoons Fe + CO_2$ by line BC in Fig. 1. The source of lines AB and BD in the same figure is not immediately evident from the text, and it would be interesting to know whether these lines were based on the Authors' own thermodynamic calculations (not reported in the present Paper) or whether they are based on the work of other investigators. The Authors go on to state "... it is evident that at temperatures inside the cupola the iron in combination with oxygen can only exist in the form of FeO as the gas concentration at these temperatures lies above the line BD." It would be interesting to learn whether the term "inside the cupola" includes the tuyere or primary combustion zone. If it does, then Fig. 1 is not applicable to this zone since Fig. 1 applies only when all the oxygen in the incoming blast has combined with carbon to form either carbon monoxide or carbon dioxide. If due allowance is made for the presence of unburned air in the tuyere zone, it appears that Fe_3O_4 is, in fact, thermodynamically stable in this zone and this would seem to contradict the Authors' assertion that "inside the cupola iron in combination with oxygen can only exist in the form of FeO."

FeO/CO Relationships

The Authors claim that for the reduction of FeO by CO in the cupola "the temperature must exceed 1,800 deg. Abs. and the gases must contain more than 23 per cent. CO." It would be interesting to know how this conclusion is reached. For example, Fig. 1 indicates that FeO can be reduced by CO in the cupola at a temperature as low as 1,100 deg. Abs. if the stack gases contain 20 per cent. or more CO. It is not clear what the Authors mean when they say "Since at the top of the cupola an excess of carbon is present, the system comes first to rest on the Boudouard curve." Perhaps they would expand this statement and indicate which "system" comes to rest at what point on the Boudouard curve.

In discussing the hearth reaction $FeO + C \rightleftharpoons Fe + CO$, the Authors show that increasing the temperature drives the reaction to the right. Because of this, they conclude that "High hearth temperatures in the cupola therefore will lead to lower FeO content in the slag." This reasoning would only be valid if the equilibrium position of the reaction $FeO + C \rightleftharpoons Fe + CO$ were the controlling factor which governs the iron-oxide content of the slag. It would be interesting to learn whether the Authors have any evidence that this is so.

Behaviour of Silicon

In discussing the behaviour of silicon in the cupola, the Authors have calculated that the free energy of the reaction:

pure silica + pure carbon $\rightleftharpoons$ pure silicon metal + carbon monoxide at one atmosphere pressure

has a negative value at temperatures greater than 1,840 deg. Abs. They therefore conclude, quite rightly, that silica can be reduced by carbon to give silicon under such conditions at these higher temperatures. However, the application of this data to the possible reactions in the cupola well is not discussed very clearly by the Authors, although they imply towards the end of this section that 1,840 deg. Abs. represents "a first approximation" to the temperature it is necessary to achieve before silicon (in the slag) can be reduced by carbon in the cupola hearth.

It is to be regretted that the Authors have not emphasized more strongly the approximate nature of their calculations concerning the reduction of silica in the cupola, and that they have not given any indication of the range of uncertainty in their estimated temperature of 1,840 deg. Abs. If they are correct in stating, on page 3 of the Preprint, that the slags in an acid-lined cupola are silica saturated and that the silicon dissolved in the iron can be considered to behave like an ideal solution, then, together with Table V, they have sufficient data to estimate the necessary temperature for silica reduction in the cupola well by the reaction:

Silica (dissolved in slag) + pure carbon (coke) = Silicon (dissolved in metal) + carbon monoxide (one atmos. pressure)

This reaction, which corresponds more closely to the events that could occur in a cupola, has also been studied thermodynamically by Richardson and Jeffes[31] who concluded that for iron containing 1 per cent. silicon, for example, it is only necessary to achieve a temperature of about 1,523 deg. Abs. for silica to be reduced by this mechanism. It is possible, therefore, that the temperature of 1,840 deg. Abs. which the Authors have calculated, might be too high by something of the order of 300 deg. However, the reaction between slag, coke and metal involves mutual contact of three independent phases, and from a geometrical point of view it would seem more probable that silica reduction in the cupola well takes place by the following reaction which involves the contact of only two phases:

Silica (dissolved in slag) + Carbon (dissolved in iron) $\rightleftharpoons$ Silicon (dissolved in iron) + carbon monoxide (one atmos. partial presure)

If this view is correct, temperatures required to reduce silica in the cupola will be somewhat higher than those calculated on the assumption that the silica dissolved in the slag is reduced by coke. A precise calculation of necessary temperature for carbon in the iron to reduce silica in the slag would only be possible if the thermodynamic activities of the carbon and silica were known in the iron and slag phase respectively. Since this information is not at present available, the necessary calculations cannot be carried out, but it is nevertheless clear that the temperature of 1,840 deg. Abs. calculated by the Authors as the necessary temperature for silica reduction in the cupola has no real significance in practical cupola operation.

Extrapolation Used

The Authors' thermodynamic treatment of the reaction represented by equation (19) has produced some interesting results which are shown in Table IV. This table includes values for $\triangle G_o$ at different temperatures ranging from 1,300 to 1,600 deg. C. These values have been calculated from the empirical relationship $\log K_{Si} = \frac{-19{,}057}{T} + 11.1008$ as formulated by Korber and Oelsen, for the temperatures above 1,527 deg. C. Perhaps the Authors would comment on the safety with which Korber and Oelsen's expression could be extrapolated down to 1,300 deg. C. It would also be helpful if they could indicate the units of $\triangle G_o$ shown in Table IV; elsewhere in the text they have expressed $\triangle G_o$ in calories and clearly indicated this in the appropriate tables. However, perhaps the most remarkable thing about Table IV is that it shows that at some temperature just below 1,723 deg. Abs. the standard free-energy change is zero and implies, therefore, that at this temperature pure silicon and pure iron-oxide are in equilibrium with pure silicon and pure iron. It would be interesting to know whether the Authors accept this, and if they feel that their treatment (on page 8 of the Preprint) of equation (19) is really relevant to the behaviour of silicon in the cupola.

Manganese and Sulphur

In their discussion of the behaviour of manganese the Authors have considered the reaction

$$MnO + C \rightleftharpoons Mn + CO$$

and have concluded that the reaction will only move from left to right if the temperature is greater than 1,700 deg. Abs. This conclusion is only valid for pure manganese-oxide reacting with pure carbon to give pure manganese and carbon monoxide at a partial pressure of one atmosphere. Since such events do not take place in the cupola, it follows that the temperature of 1,700 deg. Abs. has no particular significance for the reduction of manganese oxide by carbon in the cupola hearth. A correct estimate of the temperature at which this reaction can proceed in the cupola hearth can only be made if the activities of the reactants and resultants are taken into consideration.

In discussing the behaviour of sulphur in the cupola, the Authors imply that desulphurization

with an acid slag proceeds according to equation (42), *i.e.* with removal of sulphur *via* the gaseous phase. It is a matter of experience, however, that acid cupola slags do contain sulphur and it would be interesting to learn from the Authors whether they have considered the application of their equations (32) and (39) to sulphur distribution between cupola metal and an acid slag, and whether they have found that, in practice, the partition does actually achieve equilibrium in a cupola. If it were found in practice that equilibrium conditions are not achieved, it would indicate that desulphurization might be improved by paying attention to the factors controlling the rates of the reactions rather than their equilibrium positions. This would appear to be a most important practical consideration.

Rates of Reaction

The valuable experimental data recorded in the second part of the Paper contains indications that in seeking to explain the overall result of the chemical reactions occurring in the cupola, the *rates* at which the reactions occur cannot be ignored. As an illustration of this point, the iron-oxide content of the cupola slag may be considered. The Authors' theoretical treatment of the behaviour of iron oxide in the cupola (based only on equilibrium considerations) has led them to conclude that higher hearth temperatures will lead to lower iron-oxide contents in the slag. However, the data plotted in Fig. 15 show that the FeO content of the slag is not a unique function of the hearth temperature—*i.e.*, it does not seem to correspond in practice with an equilibrium value fixed by the reaction between the slag and coke. Fig. 15 also shows that increasing the hearth temperature can lead to *higher* iron-oxide contents of the slag, if the coke percentage is lowered at the same time. The Authors' theoretical study of chemical reactions in the cupola gives no warning of this very important practical consideration.

It would seem therefore, that the iron-oxide content of a cupola slag can be more profitably regarded as being a function of the rate at which it is formed in the cupola stack and the rate at which it is reduced in the hearth. In order to obtain a true understanding of reactions involving iron oxide, it would thus appear to be necessary to consider the rates of these reactions as well as their final equilibrium positions.

In conclusion, it seems that the Authors' excellent experimental work may be in danger of being misunderstood on account of some misleading conclusions contained in the theoretical part of the Paper. To express the physical chemistry of the cupola in a concise form is a matter of considerable difficulty, but it must be based on kinetic as well as thermodynamic considerations. The Authors may well consider any theoretical treatment to be a first approximation only to the highly complex conditions present during cupola operation, but if this is the case it would appear to be advisable specifically to state it, so that the reader does not expect to find a treatment which will answer all the questions which arise in operating practice, whether under hot- or cold-blast conditions. Nothing in these comments is intended to obscure the distinguished contributions made in the past to the study of the cupola furnace by Professor Jungbluth, to which tribute is paid.

Oil-heated Blast

MR. H. G. HALL said he could not resist the opportunity of putting a relatively simple question to such an acknowledged authority as Professor Jungbluth. Probably everyone present was conscious of the metallurgical advantages to be derived from the use of hot blast, and equally aware of the cost of the recuperative equipment to produce that hot blast. He had put a question to various people connected with hot-blast installations to which, as yet, he had not had a satisfactory answer. The question was, was it not posible to burn, say, oil in a chamber (not in the tuyeres) with the air which was used for combustion? In other words, could one put into a cupola the air which was preheated by oil to the required temperature and which contained the products of combustion of that oil? Indeed, in the Paper there was a note that the increased temperature of the hot blast resulted in a loss of efficiency in burning coke. In the case he was suggesting, one might put into the cupola hot air plus about 15 per cent. products of combustion of the oil used. Frankly, he could not see that the extra 15 per cent. would have any deleterious effect. It seemed to him that the main function of the preheated air was to intensify the reactions in the melting zone. The dilution of such preheated air with an extra 15 per cent. of fully-combusted gas at the temperature of the preheat, would surely not upset the speed of these reactions.

DR. JUNGBLUTH, in reply, said that as far as he could see at the moment the proposition mentioned by Mr. Hall would appear to be feasible, although he did not know what would be the result if the oil was burned to CO_2 and one would be blowing into the cupola CO_2 and all the reactions would change to the side of CO_2. What he had tried to show, even in the theoretical considerations, was that it was always better to change the reactions to the side of CO, and possibly that would be a difficulty with Mr. Hall's method.

The simplest method would be, if there was a blast-furnace plant in the neighbourhood to take hot blast from that for the cupola. That was done, for instance, in Saarbrücken and, of course, one then always had a blast at a temperature which was high enough. For the blast furnace, one used not the recuperator system but the regenerator system and the temperature was always high enough for the cupola and never lower than 700 deg. C.

A third method would perhaps be to enrich the blast by oxygen and in that way obtain higher temperatures. He had himself carried out such experiments, but the result was not so high as one might expect if one enriched the blast through the whole period of the melt. It was much better to give injections with oxygen, although he did not know

the reason for that, and so that third way was perhaps not always a good one.

Hot-blast from a Blast Furnace

MR. MARTIN (United States), referring to the use of blast-furnace hot-blast, asked whether the hot-blast cupola was employed commercially solely in the production of pig-iron. In other words, how did the operating characteristics of the process compare with the net result in cost of a blast furnace, or was a hot-blast cupola employed in making special pig-iron and not the ordinary run of foundry iron?

DR. JUNGBLUTH, replying, said near Stuttgart there was such a plant which made synthetic pig-

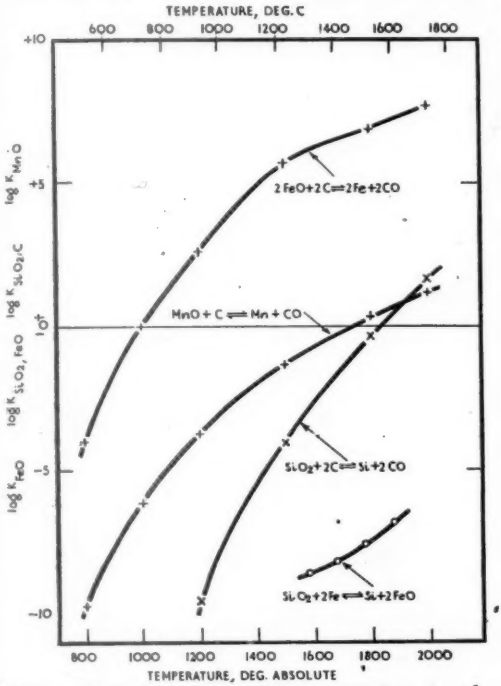


FIG. A.—*Reducing reactions occurring in the cupola.*

iron by the hot-blast cupola method, and, as far as he knew, founders liked the material very much. The difference was, of course, that only steel was charged into the cupola and the temperature was then high enough to reduce the silica to silicon and a sufficiently high silicon content was obtained in the iron which made it a good material. That method of producing synthetic pig-iron had been used in Germany for five or six years.

DR. W. OTTO ZEIL (Germany) said he thought it worthwhile to reply to the remarks made by Mr. Higgins during the earlier part of the session. A diagram shown by Mr. Higgins had as its basis the chemical potentials, the difference of which was only the free entropy which had been used by Professor Jungbluth and Dr. Stockkamp, and it was similar to the diagram produced by Mr. Fleming. It was clear that the use of those reactions was only the first step to coming near to the conditions in the cupola, and he thought Professor Jungbluth had expressed that quite distinctly. The second step would be the consideration of the reactivities and he had already said, in his written contribution to the discussion, that it was possible in that way to get a really better result. Mr. Higgins had stressed the necessity of considering the reactivity coefficients, and with that he agreed. There was a number of papers from men who had worked with that problem and those would be used as stepping stones to understanding the problem of the cupola. Mr. Higgins had stated that the equilibrium would never be reached; that was probably true, but it was not their problem. At the moment the German workers were only interested to see if a reaction was

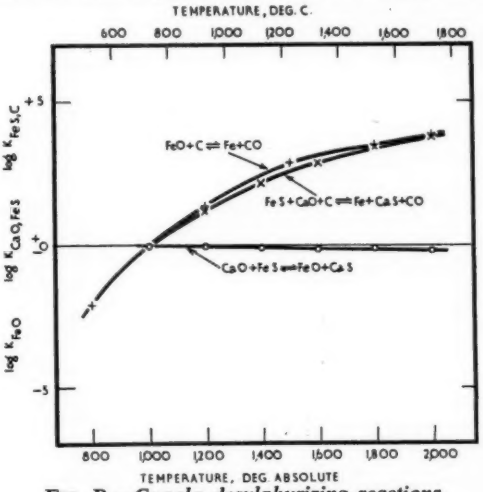


FIG. B.—*Cupola desulphurizing reactions.*

possible in one direction or not; it was a problem of the silicon pick-up.

WRITTEN COMMENT

MR. J. G. SHAW wrote that he was disappointed with the large amount of fundamental thermodynamics in this Paper, and the comparatively small amount of practical results. Nevertheless, the results given were interesting and useful. He would like to ask Professor Jungbluth two questions:

(i) One of the means of preventing reduction of the CO_2 to CO—an endothermic reaction—was to remove the cupola gases from the cupola before this reaction took place. Professor Jungbluth said that the FeO content of the slag would be increased. Had Professor Jungbluth carried out this experiment, and for what purpose did he use the cupola gases taken off?

(ii) Would Professor Jungbluth agree that the findings of Schenk are applicable mainly in the well

of the cupola at the liquid slag/metal interface under reducing conditions; also, that one of the main functions of the hot blast is the increased temperature in this zone which is favourable to the reduction of FeO and SiO_2?

Authors' Further Remarks

In reply to the contribution of Mr. P. B. Higgins, the Authors wrote that they would like first to make a few general observations without at once going into detail. They were a little surprised by the attitude taken by Mr. Higgins regarding their treatment of the thermodynamics of reactions to be expected in the cupola. They had made it abundantly clear that their considerations were essentially of a theoretical nature and could not therefore be applied *directly* to the problem of cupola operation. They had explained that the enthalpy of the main reactions only had been calculated, whereas in practice the enthalpy of the side reactions also must be determined.

They were not the only investigators of these processes in this manner, for Fleming[30] in his Fig. 12 had considered the metal and metal-oxide phases in their standard states. Richardson and Jeffes,[31] also, in their extensive thermodynamic work, in general had concentrated upon the enthalpy of standard-state reactions and only in a few cases had the effect of concentration upon the free enthalpy been considered. The co-worker of the investigator mentioned first, Dr. W. Zeil, had also examined the enthalpy of the side reactions at least for the silica reduction, and had calculated the alteration in the temperature which such a reduction entailed. A discrepancy between the value obtained by Dr. Zeil and that calculated by Mr. Higgins from the work of Richardson and Jeffes arose from the fact that Dr. Zeil had considered the silicon to be dissolved in the iron in the form of an ideal solution. The value of the heat-of-solution of silicon in iron as obtained by Chipman and Grant[32] had been included by Richardson and Jeffes but had not been included in the diagram shown by Dr. Zeil. Therefore, the diagram showed the principal relationships of the silica reduction and its dependence upon the concentration of silicon dissolved in the iron.

Mr. Higgins had suggested that the empirical rule —namely, that if an increase in the number of gas molecules took place then the reaction would be accelerated at higher temperatures—was sufficient to apply to this problem. This was only valid for a reaction having fixed entropy. Besides which, when using this simple rule there was no way of determining whether the temperature, above which a reaction is expected to take place, in in a technically attainable range. This was primarily the justification the Authors had for using a calculation based upon the enthalpies of the fundamental reactions. In this respect, the diagram drawn was in principle no different from those of Fleming and Richardson and Jeffes. The Authors had simply presented the free enthalpy of reaction for a single reaction, whereas the English investigators had worked out the chemical potential of the oxide, the difference being given by the reaction enthalpy.

The Authors had the feeling that Mr. Higgins had from the beginning set himself against the theoretical treatment of this problem. They believed that purely for didactic reasons there should be made available in the German literature an elementary treatment of cupola reactions from the theoretical viewpoint. They pointed to the fact that an engineer did not find it any hindrance to consider the operation of a machine from a purely theoretical standpoint—as for instance in the conception of the Carnot cycle as the ideal piston-operated heat engine, even though he knew perfectly well that this ideal heat cycle was not obtainable in practice.

The same thing applied to the oxidation and reduction processes of iron, silicon and manganese in the shaft and hearth of a cupola. From the work, it could be demonstrated that in any place in the world a cupola would be operated efficiently if in the waste gas there was a high η_v value, *i.e.*, a high content of carbon dioxide. Every founder wished to operate in the most economical fashion, and the theoretical considerations which the Authors had undertaken should serve to elucidate the inner mechanism of cupola melting and make clearer the reasons for a high carbon-monoxide content in the waste gas. As the contribution of Dr. Zeil had indicated, it was possible to extend work of this kind to cover the relationship between concentration and temperature, and this might be done in the future.

Effect of Gas Extraction

In regard to the contribution of Mr. J. G. Shaw, the Authors submitted the following observations:

(1) Mr. Shaw had mentioned the so-called Esslinger Process in which the waste gases were extracted from the shaft at a relatively low point, whereby maximum combustion to CO_2 was obtained. The Authors had no practical experience of this process, but they were of the opinion that not all the waste gas could in fact be extracted from this low point in the furnace, and that in fact a not inconsiderable proportion would find its way up the furnace shaft. Since this gas was high in CO_2, the Authors considered that on theoretical grounds the FeO content of the slag was likely to be increased. For the same reason a very high silicon-loss was likely to be found with this process. In the Esslinger process, the drawn off gases were used for preheating in a recuperator, and in practice this could only mean using their sensible heat, since the CO content of these gases was low—or at least should be low—according to the Patent, and thus they could not be used except in very small measure as heating gases.

(2) The Authors had no more direct knowledge than Schenck regarding the composition of the atmosphere at the slag/metal interface, and they had assumed this to be predominantly a CO-containing atmosphere.

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[30] FOUNDRY TRADE JOURNAL 95 (1953) 349-357 and 401-405

[31] *J I & S.I* (1949) 397

[32] *Trans* Amer. Soc. for Metals, 28 (1942) 365

Book Reviews

Tungsten by K. C. Li and Chung Yu Wang; published by Chapman and Hall, Limited, 37, Essex Street, London, W.C.2. Price 112s. net.

The reviewer disagrees entirely with the opening statement in the very interesting foreword, wherein Mr. Li says that "Its use [tungsten] in the manufacture of high-speed steel was not perfected until the 1914 war." Dating from 1900, not only were excellent qualities of high-speed tool steel made in Sheffield and regularly shipped to the USA, but the addition of vanadium was also practised. Molybdenum was also used and cobalt too was added. However, the statement quoted may be quite true so far as America is concerned, for it is from that country that the book emanates. In the first chapter reference is made to the Taylor and White invention and the introduction of vanadium. The geology of tungsten is dealt with very exhaustively as one of the authors pioneered the early development of Chinese wolframite and indeed was the discoverer of the ore there. Next the dressing of the ore comes in for exhaustive consideration. The chapter on the metallurgy of tungsten seems to include all the various processes which have been invented for this purpose but through a neat recapitulation they are reduced to those which have found a place in practice. From the bibliography it is obvious that the literature on the subject is indeed of large proportions, yet it is reasonably certain new applications for the metal will still be found. The chemists in the research laboratories of large works will find chapter VI of real value in their work, for detailed processes are outlined for the determination of the various elements found in association with tungsten.

For the foundryman, the interest in tungsten is limited, but it has been used in association with molybdenum for valve-seat inserts for motor-car and lorry engines. Then, too, there is the Stellite group of alloys. It is an interesting commentary that in a book on tungsten it should have been thought desirable to include a chapter on substitutes, but perhaps the answer is provided by the concluding section on economics, which details the sources of the metal, showing China as the potentially greatest source of supply. Being an authoritative work on the subject it has deservedly reached its third edition—a good recommendation.

Birth and Development of the Geological Sciences, by Frank D. Adams; published by Dover Publications Inc., 920 Broadway, New York, 10, USA. Price $1.95. (Cloth bound, $3.95.)

This is not a treatise on geology, but a history of all the facts and fancies which are and have been associated with this science. It shows on every page, intense research into historical documents and books, and from them a fascinating story has been compiled. Some of the older beliefs are to the modern reader quite fantastic, but every phase of study must start from zero—the zero in geology usually being the Creation according to Genesis and the "Flood." After a very interesting introduction, the author covers classical times, then the Middle Ages, whilst the later chapters deal with the works of Agricola, Werner and Berzelius and the Neptunian theory. Other chapters are devoted to the origin of metals, mountains, earthquakes and springs. Some of the views on origins show considerable ingenuity. One savant writing in 1700 decided that earthquakes were due to mixtures of iron and sulphur! The book runs to 506 pages and carries 92 illustrations.

Publications Received

Trade Fairs Overseas—Hints for United Kingdom Exhibitors. Published for the Board of Trade by Her Majesty's Stationery Office, York House, Kingsway, London, W.C.2; price 1s. net.

Unless meticulous attention is given to participation in overseas trade fairs, much money can be thrown away and heavy disappointment experienced. Thus it is well worthwhile getting information from every likely source and obviously, the Board of Trade is in a specially-well-placed position not only to give advice but to put generalities into print. The reviewer has but a limited experience of exhibiting abroad, but he is cognisant of the difficulties to be associated with the appointment of a suitable agent in a foreign country—especially for the late-comers embarking upon representation in Near East countries. The general question is dealt with in section 4, which very intelligently covers the broad principles of responsibility. Where a trade fair is obviously international, then the local agent cannot be expected to pay the whole cost of the stand, when he only benefits from domestic orders. The question of the standardization of stands comes in for discussion in section 5, and local conditions must be carefully considered. Whilst this booklet does not tell the whole story—no booklet could—it does give warnings against the major pitfalls.

Guide to the Factory Acts. Prepared for its members by the National Light Castings Ironfounders' Federation, 145, St. Vincent Street, Glasgow, C.2.

This is a most useful work of reference on the subject of the Factory Regulations. Wisely an index occupies the first page, where the main headings are to be found, but it should be consulted in association with the list of statistics, etc., set out on pages 17 and 18. The arrangement of the booklet is set out under five main headings: Health; Safety, Welfare: Women and Young Persons; and miscellaneous. It is rightly pointed out that this is a "guide" and that for complete authoritative information on any one point, reference must be made to the official publications. Yet it is extremely useful because there are so many small matters, such as the provision of drinking water, that can be overlooked. The recommendation—which Sir George P. Barnett has written in the foreword—as to its usefulness as a means of ready reference is to be endorsed by the reviewer.

Exempli Gratia. A brochure covering the activity of the David Brown Companies.

This otherwise very fine brochure is marred by the inclusion of too many composite pictures—a form of illustration which the reviewer cordially dislikes. This aversion is due to an inability to concentrate on one portion without having attention drawn away by something which he deems much less interesting. Despite this criticism there are some beautiful pictures, which cannot fail to merit unstinted praise.

The Present—The Future. The General Electric Company, Limited, has issued a particularly pleasing brochure which illustrates and captions "The Present" with a remarkably wide range of equipment, they have supplied both at home and abroad. "The future" is dealt with quite differently, and here well-worded letterpress is interspersed with illustrations of what has only been recently applied or is in the development stage. The whole makes very interesting reading.

New Patents

(Copies of complete specifications are obtainable from the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, London, W.C.2, price 3s.)

740,084. Buders'sche Eisenwerke, 52-56, Sophienstrasse, Wetzlar, Germany.

An installation for the transporting of cast moulding boxes from a conveyor *via* an emptying station and back to moulding machines. Moulding boxes are transported on a track extending from the conveyor as far as the moulding machine and including the emptying station by the direct (or indirect) action of one or more automatically-operated driving mechanisms, distributed along the track, and feeding the boxes.

740,159. Régie Nationale des Usines Renault, 8-10, Avenue Émile Zola, Billancourt, Seine, France.

An improved method of manufacturing a lost-wax precision-casting mould. A model in wax or equivalent plastic is covered with a coating consisting of refractory grains in a solution of alkaline silicate. The coated wax model is then placed in a frame which is filled with a mixture of suitable sand, binder, and water. This particular improvement concerns the rendering of the coating insoluble to water by treatment with a solution of a metallic salt, the silicate of which does not dissolve in water and in particular of a calcium or magnesium or aluminium salt in a solvent which does not dissolve the alkaline silicate.

740,246. Glacier Metal Company, Limited, 368, Ealing Road, Alperton, Wembley, Middlesex.

A composite bearing material of which the bearing surface layer consists of an aluminium/tin alloy containing from 10 to 20 per cent. of tin with or without cadmium or lead not exceeding a total of 2 per cent. of the aluminium content and in which other alloying elements or impurities, if present, do not exceed a total of more than 0.02 per cent. of the aluminium content.

740,268. General Motors Corporation, Grand Boulevard, Detroit, Michigan, USA.

A method of coating titanium with aluminium. A titanium part is immersed in a fused-salt composition which is capable of absorbing aluminium and titanium oxides and of undergoing activation by contact with aluminium. The salt-coated titanium is then immersed in molten aluminium to acquire an aluminium coating. This process is admirably suited to the joining of aircraft propellor-blade halves. The titanium base alloy should consist of: chromium, 3.0; iron, 1.50; oxygen, 0.5; nitrogen, 0.04; tungsten 0.08 (max), and carbon 0.02 per cent., the balance being commercially-pure titanium.

740,275. Electric Furnace Products Corporation, Limited, Canada Life Building, City of Toronto, Ontario, Canada.

A method of making a nodular cast iron which involves temperatures no higher than ordinarily encountered in making grey cast iron. Calcium is added to a molten bath of cast iron which contains sulphur not more than 0.05 and silicon at least 0.75 per cent. There is then added calcium 0.25 to 1.5 inclusive of weight of iron, zirconium 0.25 to 1.6 per cent., inclusive of weight of iron. Silicon is added if necessary to raise the silicon content of the iron to 1.5 to 5 per cent. inclusive. The temperature of the bath need not exceed 1,500 deg. C.

Changes of Name

Among companies which have recently changed their names are those listed below. The new titles are given in parentheses.

L. Chivot, Limited, Ordnance Mill, Blackburn (U.L.G. Tool Company, Limited).

Aircraft Hydraulic Appliances, Limited, Arle Court, Cheltenham (Dowty Exports, Limited).

Granby Metal Products, Limited, 359, Canal Road, Bradford, 2 (Granby Box Company, Limited).

Morrison Automatic Pumps, Limited, 4, Wycliffe Street, Leicester (Morrison Pumps, Limited).

Clifford E. Brewer, Limited, 38, Poole Road, Westbourne, Bournemouth (Pneumatic Power Plant, Limited).

Philsan Engineering Company (Letchworth), Limited, 14, London Road, Stevenage (Letchworth Components, Limited).

Penge Lead Works, Limited, St. George House, 44, Hatton Garden, London, E.C.1 (Penge Lead & Ironworks, Limited).

Ferry Engine Company, Limited, Wharf Road, Woolston, Southampton (Ferry-Diamond Engineering Company, Limited)

Advanced By-Products & Coke Oven Developments, Limited, 118, New Street, Birmingham, 2 (F. J. Collin (U.K.), Limited).

Harvills Hawthorn Engineering Company, Limited, 14, Pall Mall, London, S.W.1 (Leabrook Engineering Company, Limited).

Ming Ware, Limited, manufacturers of press tools, precision pressings, etc., of Cricklewood, London, N.W.2 (Ming Instruments, Limited).

Vicary & Penlington, Limited, agricultural machinery manufacturers, etc., of Mill End, Kenilworth (O. M. Vicary's Motors, Limited).

Wolverhampton Steel & Iron Company (1945), Limited, Osier Bed Works, Wolverhampton (Wolverhampton & Birchley Colliery Mills, Limited).

Sandford Repairing Company, Limited, general engineers, shiprepairers, etc., of 329, New Chester Road, Birkenhead (New Sandford, Limited).

Increases in Capital

Cravens, Limited, Sheffield, increased by £300,000, in £1 ordinary shares, beyond the registered capital of £550,000.

Vickers-Armstrongs, Limited, increased by £5,000,000, in £1 ordinary shares, beyond the registered capital of £30,000,000.

Vickers-Armstrongs (Engineers), Limited, increased by £13,999,900, in £1 ordinary shares, beyond the registered capital of £100.

London Scottish Foundry, Limited, Leeds, increased by £14,500, in £1 ordinary shares, beyond the registered capital of £25,000.

Guest, Keen & Nettlefolds, Limited, increased by £12,000,000, in £1 ordinary shares, beyond the registered capital of £23,000,000.

Radiation, Limited, London, W.1, increased by £2,000,000, in £1 ordinary shares, beyond the registered capital of £5,000,000.

Speedwell Gear Company, Limited, Birmingham, increased by £50,000, in 5s. ordinary shares, beyond the registered capital of £130,000.

Crofts Engineers (Holdings), Limited, Bradford, increased by £1,000,000, in 5s. ordinary shares, beyond the registered capital of £1,500,000.

Sadler & Company (Coke Ovens), Limited, Middlesbrough, increased by £146,574, in £1 ordinary shares, beyond the registered capital of £100.

Contracts Open

The dates given are the latest on which tenders will be accepted. The addresses are those from which forms of tender may be obtained. Details of tenders with the reference ESB can be obtained from the Board of Trade Export Services Branch, Lacon House, Theobalds Road, London, W.C.1 (telephone: CHAncery 4411, ext. 738 or 771), unless otherwise stated.

HUDDERSFIELD, December 12—Cast-iron pipes, special castings, and surface boxes for the 12 months ending December 31, 1956, for the Waterworks Department. The Waterworks Engineer, 24, Ramsden Street, Huddersfield.

LONDON, S.W.18, December 16—Iron castings for the period commencing April 1, 1956, for Wandsworth Borough Council. The Borough Engineer, Municipal Buildings, Wandsworth, London, S.W.18.

PAKISTAN, December 17—Galvanized netting and pipes and fittings, for the Director-General of Supply and Development, Government of Pakistan. (ESB/25083/55.)

IRAQ, December 7—Cast-iron and brass weights, for the Ministry of Interior, Directorate-General of Municipalities, Bagdad. (ESB/25039/55.)

Forthcoming Events

DECEMBER 5

Institute of British Foundrymen

Sheffield and district branch: "Mechanized Foundries and their Control," by H. A. Fox, 7.15 p.m., at the Sheffield College of Commerce and Technology, Department of Engineering, Pond Street.

DECEMBER 6

Institute of British Foundrymen

Slough section: "Mechanization of a Small Foundry," by R. Blandy, 7.30 p.m., at the Lecture Theatre, High Duty Alloys Limited.

Incorporated Plant Engineers

Edinburgh branch: "An Introduction to Atomic Energy," by J. A. Dixon, M.A., 7 p.m., at 25, Charlotte Square.
London branch: "Incentive Bonuses for Maintenance Workers," by A. J. Speakman, 7 p.m., at the Royal Society of Arts, John Adam Street, Adelphi, W.C.2.

Institute of Industrial Supervisors

Newark section: "The Foreman and the Metallurgist," by G. L. Harbach, 7.30 p.m., at the Robin Hood Hotel.

Institute of Chemical Engineers

North Western branch: "Impact of Industry on the Young Chemical Engineer," by H. Fossett, 7 p.m., at the Grosvenor Hotel, Chester.

Institute of Metals

South Wales local section: "Refractories and Fluxes," by J. White, D.Sc., Ph.D., 6.45 p.m. in Department of Metallurgy, University College, Singleton Park, Swansea. 6 p.m. (Refreshments in the College Refectory.)

Sheffield Metallurgical Association

"Production Control Quantometer for Steelworks Analysis," by D. Manterfield and W. Sykes, 7 p.m., in the Engineering Lecture Theatre, The University, St. George's Square. (Joint meeting with Iron and Steel Institute, the Royal Institute of Chemistry and the Society of Engineers and Metallurgists.)

Purchasing Officers' Association

Manchester district branch: "Timber," by T. A. Storey, 7 p.m., at the Engineers' Club, Albert Square.

DECEMBER 7

Institution of Works Managers

London branch; Industrial Engineering Division: "Industrial Engineering and Productivity," by Mr. W. J. Worsdale, 7 p.m., at the Waldorf Hotel, Aldwych, W.C.2.

Institute of Fuel

London section: "Power, Population and Productivity," by Dr. A. Parker, C.B.E., 5.30 p.m., at the Institution of Civil Engineers, Great George Street, S.W.1.

Institution of Production Engineers

Halifax graduate section: "Public Speaking," by W. F. S. Woodford, 7.30 p.m. at the White Swan Hotel.
Coventry section: "Shipbuilding," by J. Brown, 7 p.m., at Craven Arms, High Street.
Nottingham section: "Colour as an Aid to Production," by Miss P. Raine. 7 p.m. at Victoria Station Hotel.

Institute of Vitreous Enamellers

Southern section: "Design and Production of Enamelled Signs," by P. H. Mason and L. Godden, 7.30 p.m., at the Howard Hotel.

DECEMBER 8

Institute of British Foundrymen

Beds/Herts section: "Production of Moulds and Cores by the CO_2 Process" (and film), by A. Talbot, 7.30 p.m. at the Small Assembly Room, Town Hall, Luton.
Burnley section: "Some Practical Experiences With a Small Water-cooled Cupola," by F. Lord, 7.30 p.m., at the Burnley Technical College, Ormerod Road.

Institute of Industrial Supervisors

Dudley section: "Morale and Discipline under Full Employment," by L. Leonard, 7.30 p.m., at Newey Bros.

Institution of Production Engineers

Rochester section: "Lock Design and Manufacture," by C. G. Smith, 7.30 p.m., Assembly Room, Sun Hotel, Chatham.

DECEMBER 9

Institute of Industrial Supervisors

Leicester section: "Incentives," by R. G. Hooker, 7.30 p.m., at the Brush Electrical Engineering Company, Limited, Loughborough.

Institute of Fuel

North-Western section: Symposium of short papers: "Coke Manufacturing Problems," by Dr. G. E. Foxwell, C.B.E.; "Coke Utilization," by E. H. Coley; and "Smoke Problems" by Dr. Andrew Semple. 2.30 p.m., at the Engineers' Club, Albert Square, Manchester.

Purchasing Officers' Association

South of England branch: Films—"Hot Rolling of Steel" and "Cold Rolling of Steel," 7.30 p.m., at the Polygon Hotel, Southampton.

DECEMBER 10

Institute of British Foundrymen

West Riding of Yorkshire branch: "Aspects of the New Foundry Regulation Relating to Dust Generation and Control in Foundries," by W. H. White, F.R.S.A., 6.30 p.m., at the Technical College, Bradford.
Newcastle and district branch: "Efficient Production Methods for Machine Tool Castings," by G. W. Nicholls, 6 p.m., in the Neville Hall, Westgate Road, Newcastle-upon-Tyne.
East Midlands branch: "Dust and Fume Extraction in Foundries," by J. A. Wilkins, 6 p.m., in the Gas Showrooms, Nottingham.
Scottish branch: "Further Notes on the Water-cooled Cupola," by Mr. W. Y. Buchanan, 3 p.m., at the Royal Technical College, George Street, Glasgow.
Bristol and West of England branch: "Some Foundry Problems," by G. J. Rogers, 3 p.m., at the Grand Hotel, Bristol.

Institution of Production Engineers

Luton graduate section: Works visit to National Physical Laboratories, Teddington, 2 p.m.

Company News

TRIPLEX FOUNDRY COMPANY, LIMITED—The board has concluded a provisional agreement for the purchase of the whole of the issued share capital of the Great Bridge Foundry Company, Limited, Great Bridge, Tipton (Staffs).

HILL TOP FOUNDRY COMPANY, LIMITED—The offer by Associated Electrical Industries, Limited, to acquire the ordinary share capital of the company has been accepted by holders of more than 90 per cent. of the ordinary shares. The offer, which is of 4s. 6d. for each 1s. share, remains open for acceptance by those holders who have not yet accepted.

HERBERT MORRIS, LIMITED, cranemakers, etc., of Loughborough (Leics)—Despite shortages of steel and skilled labour, the value of sales for the year to July 31 was the highest in the history of the company, according to Mr. F. Morris, chairman. He hesitates, however, to forecast the future in view of the present uncertain state of industrial conditions in relation to skilled labour and material.

G. D. PETERS & COMPANY, LIMITED, manufacturers of railway rolling stock, etc., of Slough (Bucks)—The directors state that an approach has been made as a result of which an offer may be made for the shares of the company early in the new year "at a price which should represent a value somewhat in excess of the present market value." Shareholders will be advised as soon as the directors are in a position to issue further information.

JOSEPH LUCAS (INDUSTRIES), LIMITED—Only a substantial increase in volume of output enabled the company to get through the year ended July 31 last without imposing price increases of a substantial nature, states Mr. A. B. Waring, chairman, in his review. The price of copper, the principal raw material for the manufacture of electrical equipment, rose by 70 per cent. and lead and zinc by 21 per cent. and 16 per cent., respectively. Further, wages in the engineering industries were raised by 5 per cent. If the present volume of output were to fall, adds Mr. Waring, there would be the utmost difficulty in keeping down prices at anything like their present level.

Pig-iron and Steel Production

Statistical Summary of August Returns

The following particulars of pig-iron and steel produced in Great Britain are from statistics issued by the British Iron and Steel Federation. Table I summarizes activities during the past six months. Table II gives production of steel ingots and castings in August, and Table III, weekly average production of finished steel. Table IV gives the production of pig-iron and ferro-alloys in August, 1955, and furnaces in blast. (All figures weekly averages in thousands of tons.)

TABLE I.—*Iron and Steel Price Index and General Summary of Pig-iron and Steel Production.*

Period.	Price Index. 1938 = 100.			Iron-ore output.	Imptd. ore used.	Coke to blast-furnaces.	Pig-iron, ferro-alloys prod.	Scrap used in steel prod.	Steel (incl. alloy).			
	I. & S.	Coal.	All comdts.						Imports.[1]	Prod. ingots, castings.	Delivrs. finished steel.	Stocks.[2]
1953	260	350	323	304	207	237	215	188	17	339	262	962
1954	263	364	325	299	234	238	229	198	7	356	277	831
1955—Mar.[3]	269	374	331	322	239	244	241	225	28	395	321	808
April	269	374	329	310	234	242	238	224	29	393	311	844
May ..	269	366	328	313	245	242	242	228	26	402	325	859
June[3]	269	368	331	263	223	221	217	206	31	364	286	866
July ..	272	423	338	294	230	241	231	170	29	308	255	999
Aug.[3]	283	424	338	307	244	245	236	189	36	345	—	1,197

TABLE II.—*Weekly Average Production of Steel Ingots and Castings in August*, 1955.

District.	Open-hearth.		Bessemer.	Electric.	All other.	Total.		Total ingots and castings.
	Acid.	Basic.				Ingots.	Castings.	
Derby, Leics., Notts., Northants and Essex ..	—	3.6	13.7 (basic)	1.6	0.1	18.2	0.8	19.0
Lancs. (excl. N.W. Coast), Denbigh, Flints. and Cheshire	1.2	29.6	—	1.6	0.4	31.7	1.1	32.8
Yorkshire (excl. N.E. Coast and Sheffield) ..								
Lincolnshire	—	37.1	—	—	0.1	37.1	0.1	37.2
North-East Coast	0.8	68.0	—	1.2	0.3	68.7	1.6	70.3
Scotland	3.1	38.4	—	2.1	0.4	42.2	1.8	44.0
Staffs., Shrops., Worcs. and Warwick ..	—	16.2	—	1.1	0.7	16.2	1.8	18.0
S. Wales and Monmouthshire	3.5	65.2	6.7 (basic)	0.7	0.1	75.7	0.5	76.2
Sheffield (incl. small quantity in Manchester) ..	7.3	25.3	—	9.0	0.4	40.4	1.6	42.0
North-West Coast	—	1.3	3.9 (acid)	0.3	0.1	5.5	0.1	5.6
Total	15.9	284.7	24.3	17.6	2.6	335.7	9.4	345.1
July, 1955	14.8	251.7	21.9	17.1	2.2	299.3	8.4	307.7
August, 1954	14.7	272.8	21.5	13.9	2.7	317.5	8.1	325.6

TABLE III.—*Production of New Non-alloy and Alloy Finished Steel.*

Product.	1953.	1954.	1954.	1955.	
			July.	June.	July.
Non-alloy steel:					
Ingots, blooms, billets and slabs[4]	4.7	5.1	3.6	4.9	3.9
Heavy rails ..	8.7	9.6	8.2	7.1	9.0
Sleepers, etc. ..	2.2	1.9	1.3	1.6	1.9
Plates ¼ in. thick and over ..	46.5	47.0	31.4	42.2	36.5
Other heavy prod.	43.9	45.8	34.7	47.8	35.0
Ferro-concrete rods, etc. ..	5.1	5.9	5.8	5.9	6.2
Wire rods (incl. coiled rods, etc.)	15.6	19.7	12.2	22.5	13.9
Light rolled prod.	44.2	41.2	32.3	44.1	36.9
Bright steel bars ..	6.7	6.3	5.2	7.7	6.8
Hot-rolled strip ..	18.8	21.7	17.5	25.2	20.1
Cold-rolled strip ..	5.2	7.0	6.0	8.1	7.1
Sheets, incl. coated tinplate, terne-plate and black-plate	34.1	38.8	32.6	41.0	37.0
Steel tubes and pipes	14.9	16.8	14.9	16.4	16.1
Tube and pipe fittings (excl. flanges)	20.1	20.0	18.1	20.9	22.2
Tyres, wheels and axles	0.3	0.4	0.4	0.4	0.4
Forgings (excl. drop forgings) ..	4.4	4.7	3.7	4.0	5.2
Steel castings ..	3.1	2.6	2.2	2.4	2.1
Tool and magnet steel	4.0	4.0	3.0	4.3	3.2
Total	0.3	0.2	0.2	0.2	0.3
Alloy steel	282.8	298.7	233.3	306.7	263.8
Total deliveries from U.K. prod.[5] ..	13.7	13.2	10.6	14.6	12.8
Add: Imported finished steel ..	296.5	311.9	243.9	321.3	276.6
Deduct: Intra-industry conversion[6] ..	6.8	5.0	2.3	14.7	18.1
	303.3	316.9	246.2	336.0	294.7
	42.6	41.5	30.8	50.8	41.2
Total net deliveries of new material ..	260.7	275.4	215.4	285.2	253.5

TABLE IV.—*Production of Pig-iron and Ferro-alloys during August*, 1955.

District.	Furnaces in blast	Hematite.	Basic.	Foundry.	Forge.	Ferro-alloys.	Total.
Derby, Leics., Notts., Northants and Essex	25	—	16.4	24.6	1.4	—	42.4
Lancs. (excl. N.W. Coast), Denbigh, Flints. and Cheshire ..	6	—	14.1	—	—	1.9	16.0
Yorkshire (excl. N.E. Coast and Sheffield) ..	—	—	—	—	—	—	—
Lincolnshire ..	10	—	35.7	—	—	—	35.7
North-East Coast	22	4.3	48.3	—	—	1.5	54.1
Scotland	9	—	15.7	2.2	—	—	17.9
Staffs., Shrops., Worcs., and Warwick ..	7	—	9.5	1.3	—	—	10.8
S. Wales and Monmouthshire	10	4.5	33.9	—	—	—	38.4
Sheffield	1	—	1.9	—	—	—	1.9
North-West Coast	8	18.5	—	0.1	—	0.4	19.0
Total ..	98	27.3	175.5	28.2	1.4	3.8	236.2
July, 1955 .	98	25.6	172.8	26.9	0.8	4.7	230.8
August, 1954 ..	98	29.4	169.3	24.1	1.1	3.5	227.4

[1] Weekly average of calendar month.

[2] Stocks mainly ingots and semi-finished at the end of the years and months shown.

[3] Five weeks, all tables.

[4] Other than for conversion into any other form of finished steel listed

[5] Includes finished steel produced in the U.K. from imported ingots and semi-finished steel.

[6] Material for conversion into other products also listed in this table.

News in Brief

THE OVENS of the NCB's £10,000,000 coal carbonization plant at Wingerworth, near Chesterfield, will be lit on December 29.

THE Federation of Light Metal Smelters announces that its members' average selling prices for October, to the nearest 10s., were as follow:—LM1, £187 10s. per ton; LM2, £189; LM4, £192; LM6, £196.

MACHINE-TOOL ORDERS in August are reported at a value of £7,940,000, compared with total deliveries of £5,297,000. The industry's total order-book reached £95,278,000, of which £21,234,000 was for export.

THE OCTOBER ISSUE of the *Nickel Bulletin* includes a series of interesting items on cast iron, covering thermal-shock resistance, the properties of low-expansion nickel-alloy irons and oxidation-resistance of high-alloy types.

THE FORMATION of a new technical and professional association—the Federation of Engineering Design Consultants—is announced. Headquarters, for the time being, will be St. Stephen's House, Westminster, London, S.W.1.

ABOUT 2,500 applications for a maintenance memorandum were received recently in response to a letter addressed to 25,000 industrialists by Sir Leslie Hollinghurst, chairman of the National Industrial Fuel Efficiency Service.

EIGHT SHIPS worth over £10,000,000 have been ordered from Smith's Dock Company, Limited, North Shields and South Bank, Middlesbrough. Seven are oil tankers of 18,000 tons d.w. and the eighth is a 10,000-ton cargo vessel.

THE Council of the Institute of Metals has appointed a nuclear energy committee with the object of stimulating interest in metallurgical problems arising in connection with the industrial and scientific aspects of the use of nuclear energy.

EXTENSIONS are nearing completion at the Eastfield, Peterborough, factory of F. Perkins, Limited, diesel-engine manufacturers, and production should start early next year. The additions comprise 11 new bays and a further 150,000 sq. ft. of working space.

NEW ORDERS, worth over £5,000,000, to build seven ships, have been announced by William Gray & Company, Limited, West Hartlepool. Two vessels of 11,000 tons d.w., two of 7,000 tons, and one of about 9,350 tons are for various British owners, while two of about 12,000 tons are for a Greek owner.

THE National Industrial Development Council of Wales & Monmouthshire, Limited, which was established in 1932, is to be disbanded at the end of the year. Members will hear the liquidator's final report on January 12. The Council was founded to attract new industries to Wales and to help existing concerns to expand.

A CENTRAL CANTEEN now being added as an extension to the staff restaurant building at the Thorncliffe works of Newton, Chambers & Company, Limited, will be capable of seating more than 500 diners—more than the general canteen and the constructional shop canteen combined—and will have the effect of centralizing the canteen service.

BEQUESTS totalling £156,144 gross are made in the will of Major Stephen John Thompson, former governing director of John Thompson, Limited, engineers, boilermakers, etc., of Wolverhampton, who died on April 30. Major Thompson left £5,000 for distribution among workers employed by the company, and subsidiary or associated companies, for 20 consecutive years.

WITHIN TWO WEEKS of offering its employees in London, Hertfordshire and Lancashire a chance to become shareholders, John Dale, Limited, has had to close the application list because the offer was over subscribed. Those who had taken up the stock represented a good cross-section of the 3,000 or so employees; many of the women employees participated.

FURTHER EXTENSIONS to the training headquarters of F. H. Lloyd & Company, Limited, James Bridge, were announced by Mr. M. C. Lloyd at the annual distribution of prizes to apprentices on November 23. He said it was hoped to build a new engineering training school in the near future and concerning the firm's American scholarship scheme, it was intended to make it an annual event.

DETAILS OF CONTRACTS with British manufacturers valued at nearly £10 million have been announced by the British Transport Commission. These are for 141 main-line locomotives (130 diesel-electric, 11 diesel-hydraulic) and 30 power units required as part of the £1,200,000,000 plan for the modernization and re-equipment of British Railways. The 30 power units will be used for locomotives to be built in British Railways workshops.

TO HELP RELIEVE the acute shortage of cement in New Zealand, a new company called the New Zealand Cement Company is to be formed to operate a cement works to be constructed at Westport, New Zealand. The works will have an annual capacity of 100,000 tons. The scheme has been sponsored by the Tunnel Portland Cement Company, Limited, in association with William Baird & Company, Limited, William Cory & Son, Limited, and the Northern Mercantile & Investment Corporation.

A PREFABRICATED FACTORY in Petre Street, Sheffield, is being built for Lifting Gear Products, Limited, makers of sling chains for the steel industry, and later two more bays will be added. There had been complaints from householders near the old Earsham Street premises that the company's new welding plant interfered with radio and television sets and Sheffield Corporation asked the firm to move. A further consideration was the closeness of the annealing furnace to nearby houses.

AT the International Atomic Exposition in Cleveland, Ohio, USA, from December 10 to 16, 14 United Kingdom instrument firms specializing in the field of nuclear energy will be exhibiting some of their latest and finest instruments on an official stand taken by the Board of Trade. The display has been organized with the co-operation of the Scientific Instrument Manufacturers' Association of Great Britain, whose 140 members cover every branch of instrumentation, both laboratory and industrial.

TO MAKE BETTER KNOWN the help that British businessmen can obtain from officials of the UK Government stationed abroad, the Foreign Office and the Board of Trade have published a pamphlet called *Helping the Exporter* which is being distributed by the Association of British Chambers of Commerce, the Federation of British Industries, the National Union of Manufacturers, and the Institute of Export. Single copies are also obtainable from the Board of Trade, Room 8185, Horse Guards Avenue, London, S.W.1.

A NEW UNION, in opposition to the Amalgamated Engineering Union, has been formed by Mr. Arthur J. Noble, of Kenilworth Drive, Earby, near Skipton. It is stated that it will not employ the strike weapon and already 300 members have been enrolled over the area. It carries the title of the Union of Skilled Workers, is non-political, and opposed to the practices of closed shops, go-slow methods, and lock-outs. Mr. Noble is employed at the Barnoldswick works of Rolls-Royce, Limited, where his son is an apprentice.

AN AGREEMENT covering the manufacture in South Africa of certain types of heavy gearing has been completed by the Vanderbijl Engineering Corporation, Limited, Vanderbijl Park, and David Brown Precision Equipment (Pty.), Limited, Benoni, Transvaal. Under the terms of the agreement all the Vecor gear-cutting equipment has been transferred to the David Brown works. Vecor will produce castings and carry out the machining of all heavy gear and pinion blanks for both companies, and will also be responsible for the marketing of all products covered by the agreement.

TO SMEDLEY BROTHERS, LIMITED, Eagle Iron Works, Belper, Derbyshire, the JOURNAL extends congratulations on the attainment of their centenary. It was originally established in 1855 in Becksitch Lane as an iron foundry and engineering shop by three brothers, Alfred, James and Frederick. By 1893, when the firm became a limited company, Alfred was the original member still active in the business. It is noteworthy that since becoming a limited company every director and shareholder has borne the family name of Smedley, which is indeed an extremely rare occurrence, if not unique. To mark the centenary a dinner will be held at the River Gardens Pavilion, Belper, on December 2.

SIR GODFREY INCE, Permanent Secretary to the Ministry of Labour and National Service, suggested that the engineering industry must take full advantage of the increased supply of young people that would be available in two years' time, when he spoke at the annual apprentice prize-giving of Dowty Equipment, Limited, Cheltenham. "We are going to continue to suffer a shortage of young persons, although for a few years from 1957 onwards there will be more young persons available," he said. "These few years from 1957 onwards provide what is commonly known as 'the bulge.' I hope the engineering industry is already preparing for that period."

Obituary

THE DEATH has occurred of Mr. W. HAROLD EDWARDS, chairman of British Quadruplex, Limited, makers of valveless rotary pumps, of London, W.2.

THE DEATH is reported at the age of 78 of Mr. JOHN GEORGE MCFARLANE, a boiler designer at the Southwick engine works of George Clark & North Eastern Marine (Sunderland), Limited. He had been with the group since 1910 and was working up to the time of his death.

Mr. ARTHUR RUSSELL, whose death occurred on November 22, served his company, Goodwin Barsby & Company, Limited, for over 50 years, commencing as a boy in the drawing office, and rising to become technical director of the company in 1948. He was intimately associated with all the company's products, having a major responsibility in their design and development.

Ether Accident

Firth-Vickers Stainless Steels, Limited, Weedon Street, Sheffield, were defendants in an action at Sheffield Assizes on November 15, when £793 damages were awarded to Clarence Bennett, 33, a van driver, for personal injuries against the firm as his employers.

Mr. Castle-Miller, who appeared for Bennett, said that the plaintiff was previously a mobile crane-driver and spare-time van driver, but was on full-time van driving at the time. On June 13 he was conveying stores from one general store to another and was handed with other goods a bottle of ether with no sort or kind of warning. "I am instructed that the carrying of this ether on a hot summer's afternoon—when the temperature in the van would very easily be greater than 90 deg. F.—was the height of folly." Bennett, who had been given no instruction, put the bottle between the seats to avoid it being shaken about in the back. He could not say whether the bottle had broken as it fell over, or had exploded beside him. He had put himself over a "time-bomb" and it went off as he drove over a level-crossing. It was perfectly plain that ether should be carried in properly insulated compartments. Bennett had stopped at once when he saw liquid all over the floor, but before he could do anything it had gone up in flames, and he was badly burned.

Mr. P. Stanley-Price, for the company, claimed that they were not negligent. Bennett was responsible for the storing of the goods, and had failed to pack the bottle safely, and did not drive with the care needed to avoid upsetting it.

Mr. Justice Pilcher, in his judgment, said: "It was thought at one time that the bottle of ether might have exploded. I am not quite satisfied that it would be proper for me to find that any such explosion took place." He went on: "I have come to the conclusion that defendants cannot be acquitted of responsibility for this very unfortunate accident. The duty of an employer is to exercise reasonable care for the safety of its people." He added that the matter of whether plaintiff had contributed to the negligence had given him some difficulty. By putting the bottles in the front he had thought to keep them under his eye, and did not put them in the back because they had rattled about. But he had put them in an unstable position with the natural result that they had toppled over. His negligence was not so serious.

The judge apportioned the blame for the accident 75 per cent. to the firm and 25 per cent. to the driver, and awarded Bennett damages of £793 3s. 3d.

Board Changes

B. & S. MASSEY, LIMITED—Mr. William T. Agar has resigned from the board.

H. M. HOBSON, LIMITED—Mr. L. S. Greenland, chief designer, has been appointed a director.

KETTERING IRON & COAL COMPANY, LIMITED—Mr. S. J. Goode, secretary, and Mr. T. R. Hodson, works manager, have been appointed directors.

NATIONAL GAS & OIL ENGINE COMPANY, LIMITED—Mr. J. Jones, managing director, will relinquish the executive responsibilities of that office at the end of the year and will be deputy chairman as from January 1, when Mr. S. Webster, deputy managing director, will be appointed managing director. Mr. Jones will then be available to the other companies of the Brush Group in a consultative capacity.

Personal

THE TITLE of Emeritus Professor of Engineering has been conferred on Dr. H. W. SWIFT by the Council of Sheffield University.

THE new deputy secretary of Stewarts and Lloyds, Limited, Mr. G. H. T. MACLEOD, is continuing to act as general office manager, Scotland.

MR. A. RAYMOND KEY, has been appointed vice-president of Johnson Matthey & Company, Inc., the American associate of Johnson Matthey & Company, Limited.

MR. F. E. HUGHES has been appointed secretary of Black & Decker, Limited, in succession to MR. C. W. JOHNS, who has retired after 25 years' service with the company.

Mr. J. A. R. KAY has been appointed general manager of A. V. Roe, Limited. For the last eight years he has been executive assistant to the managing director, Sir Roy Dobson.

GENERAL ELECTRIC COMPANY, LIMITED, will open a new depot at Magnet House, Derby Street, Preston, on December 5. The new depot is under the management of Mr. R. G. GALLOWAY.

SIR HENRY SPURRIER, managing director of Leyland Motors, Limited, has been elected president of the Motor Industry Research Association. He succeeds MR. WILLIAM LYONS, Jaguar Cars, Limited.

THE CHAIRMAN of Radiation, Limited, Mr. KENNETH N. DAVIS, has been elected chairman of the executive committee of the Industrial Welfare Society, of which he has been a member for more than 20 years.

MR. F. T. BLAKEY has been appointed secretary of Armstrong Siddeley Motors, Limited. He began with Wolseley Motors in Birmingham in 1935, and moved to their S.U. carburetter factory as assistant chief accountant in 1939.

Mr. E. BRADFORD BARTON has taken over the northern area representation for the foundry division of Sheepbridge Equipment, Limited. He will operate from 51, Albert Road, Grappenhall, near Warrington, Lancs. (Telephone: Grappenhall 694.),

MR. J. C. SIMONSON has joined the board of The National Steel Foundry (1914), Limited, which was recently acquired by Lake & Elliot, Limited, of Braintree. MR. C. H. KAIN, A.M.I.MECH.E., F.I.M., has been appointed chairman and managing director.

THE President of the Board of Trade has appointed Mr. C. H. G. MILLIS to be a part-time member of the National Research Development Corporation for three years. He succeeds Sir EDWARD DE STEIN, who recently resigned from the corporation in view of his business commitments.

Mr. ARTHUR R. GOW has been appointed a director of Fairbairn Lawson Combe Barbour, Limited, Wellington Foundry, Leeds. This is the parent company of Urquhart, Lindsay & Robertson Orchar, Limited, Blackness Foundry, Dundee, of which Mr. Gow is an executive director.

A BUSINESS TOUR covering 25,000 miles is being undertaken by Mr. T. H. R. PERKINS, a director and export manager of F. Perkins, Limited, diesel-engine manufacturers, of Peterborough. He will visit Asia, Australasia, Canada, and the United States and is due home in February.

Mr. ERNEST CHAPMAN has retired from the excavator factory of Newton, Chambers & Company, Limited, after 60 years with the company. He went to Thorncliffe at the age of 13 as an apprentice moulder, and worked in the foundries until he transferred to lighter work in the excavator factory in 1948.

MR. H. P. BARKER has been appointed chairman of Parkinson & Cowan, Limited, makers of meters and gas, electric, water and ore appliances. He will succeed SIR GEORGE JESSEL, who is relinquishing the chairmanship at the end of the year, and his seat on the board, in view of other business commitments.

IN CONNECTION with the development of the Atlas Works, Pershore (Worcs), of Fisher, Humphries & Company, Limited, agricultural engineers, recently taken over by W. H. Allen, Sons & Company, Limited, engineers, of Bedford, Mr. J. P. GOODACRE has been appointed to the position of planning and plant engineer.

LORD TWEEDSMUIR has been re-elected president of the Federation of Commonwealth and British Empire Chambers of Commerce. MR. JOHN R. K. TYRE, chairman of the Federation's Council, MR. CHARLES D. GILL, deputy chairman of the Council, and MR. H. ALAN WALKER, treasurer, have also been re-elected to their respective offices.

THE British Oxygen Company, Limited, announces the appointments of Mr. A. D. SMART as secretary and Mr. K. G. PLATT as chief accountant. Mr. A. THOMAS, who joined the British Oxygen Company at the age of 16 and in 1951 was appointed accountant, has been appointed secretary and acountant of British Oxygen Chemicals, Limited.

MR. JOSEPH PARKES, managing director of Benjamin Parkes & Sons, Limited, ironfounders and sheet-metal workers, Coseley, celebrated his 84th birthday on November 23. To mark the occasion, Mr. T. L. Perry, chairman of the company, presented him, on behalf of the directors, with an automatic teamaker, and from the staff and workpeople he received an illuminated address.

AT the annual general meeting of the Transvaal Foundry Association held on September 6, MR. J. GREENHORN was elected chairman and MR. S. J. VENNING, vice-chairman. The following represent the various trade sections: MR. H. HUGHES (steel founders); MR. F. C. MILBURN (repetition founders); MR. V. L. DEAN (general founders); MR. H. G. HORRELL (shell castings).

Seventy-three-year-old MR. SAMUEL HINTON, of West Bromwich, spent all his working life, from the age of 13 to 65, with the firm of Geo. Salter & Company, Limited, and then asked to be allowed to go on working. His extra spell lasted eight years, and he retired the other day after completing just over 60 years, the last 40 of them as a chargehand. At the farewell ceremony, Mr. Hinton was presented with a cheque by Mr. C. S. Bache, chairman of the company.

Continued ill-health has led to the retirement of Sir FELIX POLE from the board of Associated Electrical Industries, Limited. He joined the company in 1929 as chairman, but later resigned to become deputy chairman and relinquished that office in 1946. In September last year he resigned from the board of the Metropolitan-Vickers Electrical Company, Limited, of which he was deputy chairman. Sir Felix, who is 78, holds among other business appointments the chairmanship of the Pulsometer Engineering Company, Limited. He was a member of the Coal Commission and a former general manager of the Great Western Railway.

BRITISH FOUNDRY UNITS, LIMITED, have been appointed sole distributors for the range of Vortec sand mixers, slurry mixers and foundry machinery as manufactured by George Tweedy & Company, Limited.

Raw Material Markets

Iron and Steel

Some sections of the foundry industry continue to be better employed than others. The engineering and speciality foundries are very busy and there is a regular flow of orders on both home and export account. The motor, tractor, and allied trades are still specifying freely, while good demands are also forthcoming from the makers of power plant and electrical equipment, machine tools, agricultural implements, and other consumers. Although substantial quantities of castings are being used at home, a large proportion of the outputs of the engineering and speciality foundries are intended for the export market. These foundries require large tonnages of pig-iron, particularly in the low- and medium-phosphorus grades. Available supplies, however, are lower than they have been for some considerable time. Hematite is also fully absorbed, supplies falling far short of requirements. Consequently, foundries are using refined irons more extensively than is usual.

Many of the light foundries have capacity available for more business. Most of the jobbing foundries have good order-books and they are taking up their normal supplies of high-phosphorus pig-iron. Makers of this grade have little difficulty in meeting current demands. In fact, quantities may have to be placed into stock, although consignments have recently been booked for shipment abroad.

Heavy cast-iron and machinery scrap are in strong demand from the foundries. Foundry coke is coming forward regularly, although many consumers are anxious to augment their stocks, which is desirable at this period of the year. Ganister, limestone, and firebricks are received to requirements.

Many re-rollers continue to be hampered by shortage of manpower. Plenty of orders are on hand and deliveries are much in arrear due to their inability to increase the number of working shifts. The supply of most grades and sizes of steel semis from home sources has improved and tonnages received from overseas have augmented stocks. Good demands continue to emanate from home consumers, while many inquiries from overseas have to be rejected owing to the inability of the re-rollers to offer reasonable delivery dates.

Non-ferrous Metals

Copper prices on both sides of the Atlantic are holding firm and in some circles it is believed that they may not come down from their present high level until near the end of the first quarter of 1956. Certainly, demand in the United Kingdom is good and has resulted in a steady price. Although refined copper stocks in London Metal Exchange warehouses showed an increase of nearly 1,000 tons recently, the backwardation has not narrowed. Continental demand is also steady, while in the United States nearby supplies remain as tight as ever.

US Custom smelters are believed to be getting 47 cents a pound for December copper and 46½ cents for January metal, a rise of 1 cent over last week in both cases. At the same time, dealers are able to sell at 48 cents in some instances, equivalent to £384 a ton, for January copper. Nevertheless, the producers' price remains at 43 cents, although it is known that all 1955 copper has been sold forward.

Tin continues to be a good market everywhere. Stocks in this country have shown a small improvement, but still remain unsatisfactorily low. New York is following London's price trend. Consumers are taking in the metal not only to meet steady consumer demand but also as a hedge against the disquieting political conditions in the Middle and Far East. There are indications that the New York price may top the $1 a pound level.

Tin mining employers in Nigeria are to pay a minimum daily rate of 2s. 8d. to the miners. This rate will not include the maize subsidy, but maize will be available at the market price. These proposals have been accepted by the unions, but they have not accepted the employers' offered increases in special grades.

Talk of a further increase in the price of lead has flared up again in the States. The market is very active and demand continues at a high level. At present the London price is above the New York parity and has been climbing higher, and there is a feeling that the American quotation will soon be put on a dearer basis. Uneasiness is growing about the actual supplies of the metal.

Demand for zinc is good on both sides of the Atlantic. The UK price is at a higher level now than at any time since free dealing began in 1953. In the US consumer demand for special high-grade metal is still in excess of available supplies.

Official metal prices were as follow:—

COPPER, Standard—*Cash:* November 24, £384 10s. to £385; November 25, £381 to £382; November 28, £381 10s. to £382 10s.; November 29, £386 10s. to £387 10s.; November 30, £389 10s. to £389 10s.

Three Months: November 24, £374 10s. to £375; November 25, £372 10s. to £373; November 28, £372 10s. to £373; November 29, £376 10s. to £377; November 30, £379 to £379 10s.

TIN, Standard—*Cash:* November 24, £775 to £776; November 25, £773 to £774; November 28, £773 10s. to £774; November 29, £777 to £778; November 30, £781 to £782.

Three Months: November 24, £765 to £766; November 25, £764 to £765; November 28, £764 to £765; November 29, £767 to £768; November 30, £771 to £772.

LEAD—*Second half November:* November 24, £109 15s. to £110; November 25, £110 5s. to £110 10s.; November 28, £111 to £111 5s.; November 29, £112 to £112 10s.; November 30, £110 to £110 10s.

Second half February: November 24, £109 5s. to £109 10s.; November 25, £109 10s. to £109 15s.; November 28, £110 5s. to £110 10s.; November 29, £110 10s. to £110 15s.; November 30, £109 15s. to £110.

ZINC—*Second half November:* November 24, £93 to £93 5s.; November 25, £93 15s. to £94; November 28, £94 10s. to £95; November 29, £96 to £97; November 30, £96 5s. to £97.

Second half February: November 24, £91 15s. to £92; November 25, £92 to £92 5s.; November 28, £92 15s. to £93; November 29, £93 5s. to £93 10s.; November 30, £94 to £94 5s.

Data Sheet

ALAR, Limited, 3, Albemarle Street, London, W.1, have issued a new edition of their well-known mounted data sheet of the standard aluminium casting alloys used for general engineering purposes. No fewer than 23 alloys are listed together with their chemical composition, physical properties, casting characteristics, corrosion resistance, machinability, related specifications, trade names, and the minimum mechanical properties specified. This useful data sheet is available to readers on application to ALAR.

first– **W20 to increase output**

then– **W42 to minimise casting odour**

Now **the lowest priced urea resin corebinder on the market**

W45

Never before has the Foundry Industry been offered such a high quality corebinding resin at such a reasonable price. Beetle W45 has all the excellent and well-known properties of W20 but offers substantial new economies in use. It is backed by the comprehensive B.I.P. Service that applies to all B.I.P. products.

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Corebinders and Coregums

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Current Prices of Iron, Steel, and Non-ferrous Metals

(Delivered unless otherwise stated)

November 30, 1955

PIG-IRON

Foundry Iron.—No. 3 IRON, CLASS 2:—Middlesbrough, £17 1s. 0d.; Birmingham, £16 13s. 3d.

Low-phosphorus Iron.—Over 0.10 to 0.75 per cent. P, £18 12s. 9d., delivered Birmingham. Staffordshire blast-furnace low-phosphorus foundry iron (0.10 to 0.50 per cent. P, up to 3 per cent. Si), d/d within 60 miles of Stafford, £19 8s. 3d.

Scotch Iron.—No. 3 foundry, £19 5s. 6d., d/d Grangemouth.

Cylinder and Refined Irons.—North Zone, £21 3s. 0d.; South Zone, £21 5s. 0d.

Refined Malleable.—P, 0.10 per cent. max.—North Zone, £22 0s. 0d.; South Zone, £22 3s. 0d.

Hematite.—Si up to 2 per cent., S. & P. over 0.03 to 0.05 per cent.:—N.-E. of England (local iron), £19 5s.; Scotland (Scotch iron), £19 11s. 6d.; Sheffield, £20 12s. 0d.; Birmingham, £20 19s. 6d.; Wales (Welsh iron), £19 11s. 6d.

Basic Pig-iron.—£16 16s. 6d. all districts.

FERRO-ALLOYS

(Per ton unless otherwise stated, delivered)

Ferro-silicon (6-ton lots and over).—45 per cent. Si, £43 15s. 0d., scale 15s. per unit; 75 per cent. Si, £65 0s. 0d., scale 16s. per unit.

Ferro-vanadium.—50/60 per cent., 23s. 8d. to 25s. 0d. per lb. of V.

Ferro-molybdenum.—65/75 per cent., carbon-free, 11s. 0d. per lb. of Mo.

Ferro-titanium.—20/25 per cent., carbon-free, £230 0s. 0d.; 38/40 per cent., £279 0s. 0d.

Ferro-tungsten.—80/85 per cent., 16s. 10d. per lb. of W.

Tungsten Metal Powder.—98/99 per cent., 19s. 10d. per lb. of W.

Ferro-chrome (6-10 ton lots).—4/6 per cent. C, £85 0s. 0d. to £90 0s. 0d., basis 60 per cent. Cr, scale 25s. 0d. to 30s. 0d. per unit; over 6 per cent. C, £82 0s. 0d. to £86 0s. 0d., basis 60 per cent. Cr, scale 24s. 0d. per unit; 2 per cent. C* 1s. 11½d. per lb. Cr.; 1 per cent. C,* 2s. 0½d. per lb. Cr; 0.15 per cent. C,* 2s. 2½d. per lb. Cr; 0.10 per cent. C,* 2s. 2¾d. per lb. Cr; 0.06 per cent. C,* 2s. 3d. per lb. Cr.

Metallic Chromium.—98/99 per cent., 7s. 0d. to 7s. 6d. per lb.

Metallic Manganese.—93/95 per cent., carbon-free, £249 0s. 0d.; 96/98 per cent., £269 0s. 0d.

Ferro-columbium.—60/75 per cent., Nb + Ta, 28s. per lb., Nb. + Ta.

Ferro-manganese (home).—78 per cent., £54 10s. 0d.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms, and Slabs.—BASIC: Soft, u.t., £26 19s. 0d.; tested, 0.08 to 0.25 per cent. C, £27 19s. 0d.; hard (0.41 to 0.60 per cent. C), £29 5s. 6d.; silico-manganese, £37 12s. 6d.; free-cutting, £31 0s. 6d. SIEMENS MARTIN ACID: Up to 0.25 per cent. C, £34 12s. 0d.; silico-manganese, £36 12s. 6d.

* Average 68-70 per cent.

Billets, Blooms, and Slabs for Forging and Stamping.—Basic, soft, up to 0.25 per cent. C, £32 11s. 0d.; basic, hard, over 0.41 up to 0.60 per cent., C, £33 13s. 6d.; acid, up to 0.25 per cent. C, £36 12s. 6d.

FINISHED STEEL

Heavy Plates and Sections.—Ship plates (N.-E. Coast), £33 1s. 6d.; boiler plates (N.-E. Coast), £35 11s. 6d.; floor plates (N.-E. Coast), £34 10s. 6d.; sectional material, N.-E. Coast, £30 19s. 6d.

Small Bars, Sheets, etc.—Rounds and squares, under 3 in., untested, £34 7s. 0d.; flats, 5 in. wide and under, £34 7s. 0d.; hoop and strip, £35 1s. 6d.; uncoated strip mill coils, hot rolled, under 3mm. to 12g., £36 5s. 0d.; black sheets (hand mill), 17/20 g., £46 13s. 6d.; galvanized corrugated sheets, 24 g., £58 11s. 0d.

Alloy Steel Bars.—1 in. dia. and up: Nickel, £58 0s. 3d.; nickel-chrome, £81 10s. 0d.; nickel-chrome-molybdenum, £92 7s. 6d.

NON-FERROUS METALS

Copper.—Cash, £389 0s. 0d. to £389 10s. 0d.; three months, £379 0s. 0d. to £379 10s. 0d.; settlement, £389 10s. 0d.

Copper Tubes, etc.—Solid-drawn tubes, 3s. 8¾d. per lb.; rods, 428s. 3d. per cwt. basis; 20 s.w.g., 461s. 6d. per cwt.

Tin.—Cash, £781 0s. 0d. to £782 0s. 0d.; three months, £771 0s. 0d. to £772 0s. 0d.; settlement, £782 0s. 0d.

Lead (Refined Pig).—Second half November, £110 0s. 0d. to £110 10s. 0d.; second half February, £109 15s. 0d. to £110 0s. 0d.

Zinc.—Second half November, £96 5s. 0d. to £97 0s. 0d.; second half February, £94 0s. 0d. to £94 5s. 0d.

Zinc Sheets, etc.—Sheets, 15 g. and thicker, all English destinations, £128 5s. 0d.; rolled zinc (boiler plates), all English destinations, £126 0s. 0d.; zinc oxide (Red Seal), d/d buyers' premises, £103 0s. 0d.

Brass Tubes, etc.—Solid-drawn tubes, 2s. 11¼d. per lb.; rods, drawn, 3s. 8¼d.; sheets to 10 w.g., 364s. 9d. per cwt.; wire, 3s. 6¼d.; rolled metal, 350s. 6d. per cwt.

Brass (Brazing).—BS1400, B3 (65/35), £226; B6 (85/15), —; BS249, £238

Brass (High Tensile).—BS1400, HTB1 (30 tons), £288; HTB2 (38 tons), £290; HTB3 (48 tons), —.

Gunmetal.—RCH, 3/4 per cent. tin, —; BS1400, LG2 (85/5/5/5), £325; LG3 (86/7/5/2), £334; G1 (88/10/2/½), £401; (88/10/2/1), £391.

Phosphor Bronze.—BS1400, PB1 (AID released), £417 per ton.

Phosphor Bronze Strip, etc.—Strip, 514s. 0d. per cwt.; sheets to 10 w.g., 537s. 6d. per cwt.; wire, 5s. 2⅝d. per lb.; rods, 4s. 6¾d.; tubes, 4s. 5d.; chill cast bars: solids 4s. 7½d., cored 4s. 8½d. (CHARLES CLIFFORD, LIMITED).

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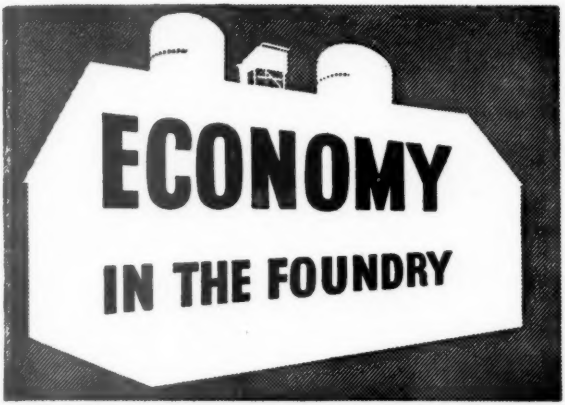

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Advertisements (accompanied by a remittance) and replies to Box Numbers should be addressed to the Advertisement Manager, Foundry Trade Journal, John Adam House, 17/19, John Adam Street, Adelphi, London, W.C.2. If received by first post Monday advertisements can normally be accommodated in the following Thursday's issue.

SITUATIONS WANTED

FOUNDRY MANAGER (29), educated to H.S.C. standard. Jobbing and mechanised alloy steel, bronze, iron. Requires similar position, would consider sales. Box FM663, FOUNDRY TRADE JOURNAL.

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The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 *inclusive or a woman aged* 18-59 *inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order,* 1952.

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METALLURGIST required by Investment Foundry to control investing, melting and heat-treatment operations.—Apply P. I. CASTINGS (ALTRINCHAM), LTD., Atlantic Street, Altrincham, Cheshire.

FOUNDRY REPRESENTATIVE required for the South of England. Foundry producing high duty irons. Salary, expenses and commission basis, with existing connections. Please state, in confidence, age and experience.—Box FR651, FOUNDRY TRADE JOURNAL.

THE GENERAL ELECTRIC CO., LTD., Witton, Birmingham, 6, invites applications for the position of FOUNDRY SUPERINTENDENT in a modern foundry which includes well-equipped pattern shops, floor moulding, bench moulding and large mechanised plants producing 4,000 tons of iron castings per annum.—Details of age, practical experience, technical training, etc., should be sent in confidence to the STAFF MANAGER.

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SITUATIONS VACANT—*contd.*

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METALLURGIST required by a firm of Engineers and Founders in Glasgow area. Experience of copper-base alloys preferred.—Please apply, giving qualifications and experience, to Box MR673, FOUNDRY TRADE JOURNAL.

FOREMAN required for small Foundry producing High Grade Medium Sized Iron Castings. Must have held similar position. West Bromwich area.—State age, experience, and salary expected to Box FR668, FOUNDRY TRADE JOURNAL.

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